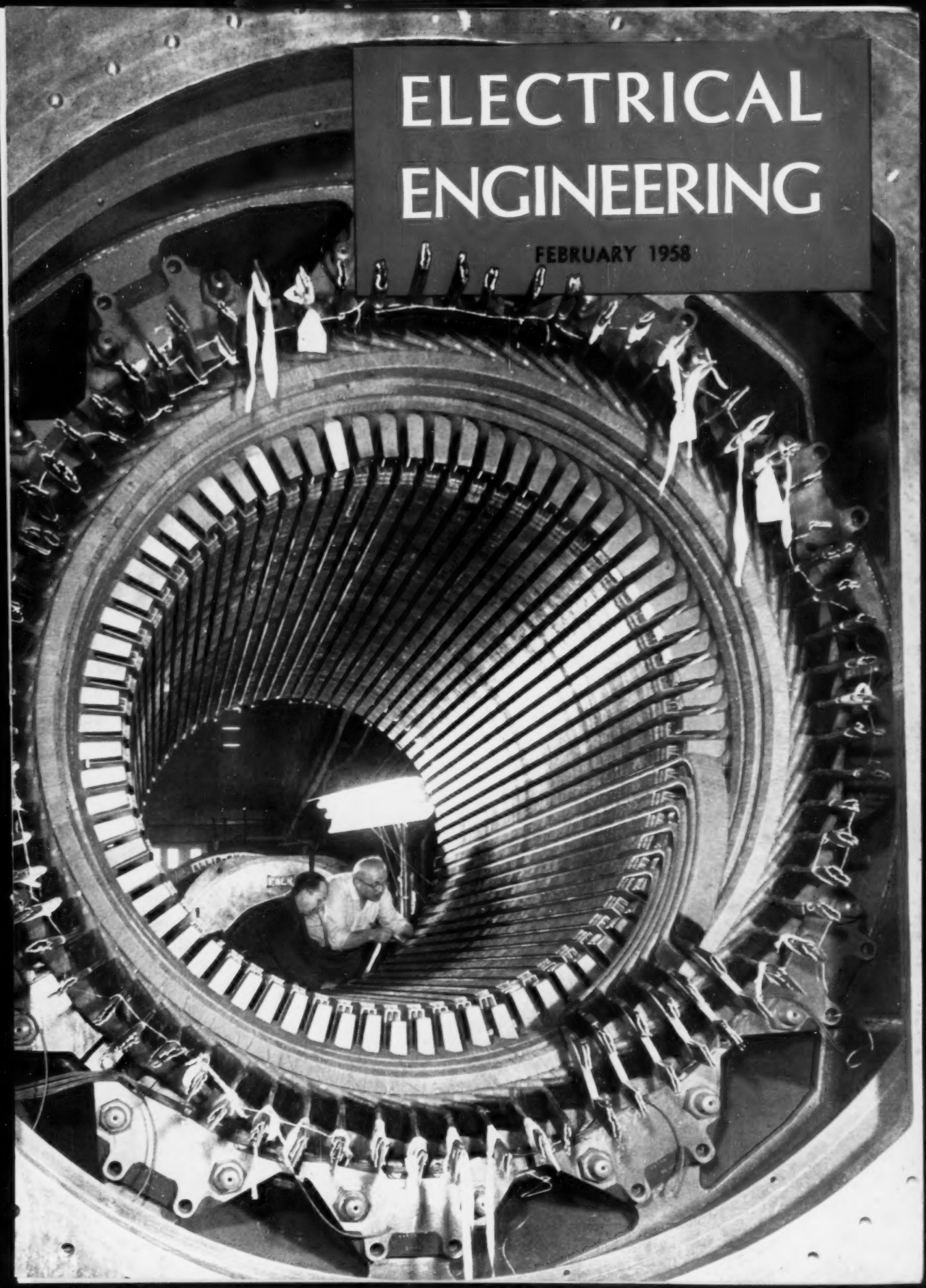
ELECTRICAL ENGINEERING

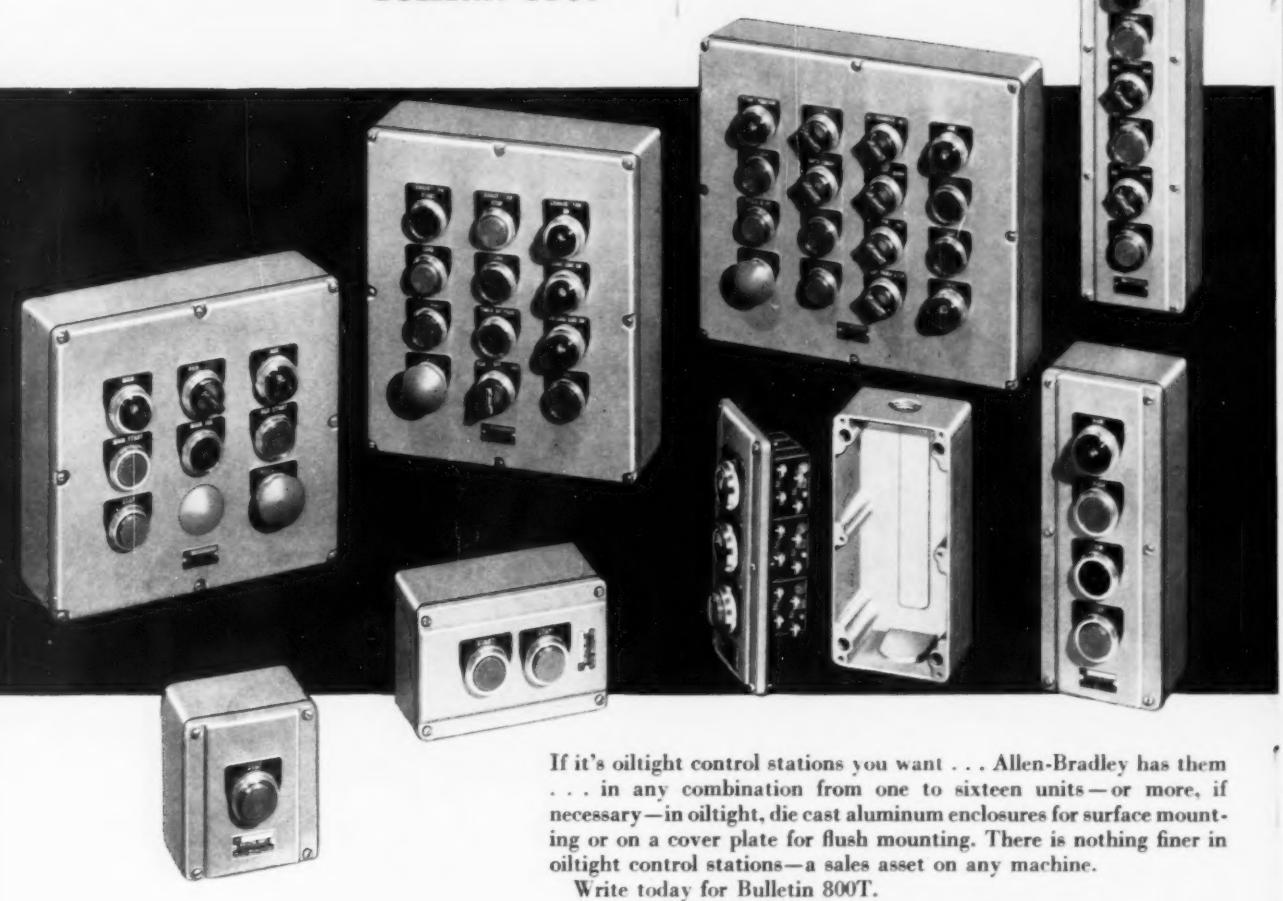
FEBRUARY 1958



NOTHING FINER IN oiltight control stations

A-B QUALITY

BULLETIN 800T

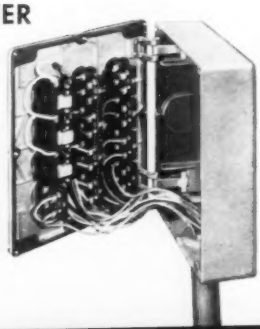


If it's oiltight control stations you want . . . Allen-Bradley has them . . . in any combination from one to sixteen units—or more, if necessary—in oiltight, die cast aluminum enclosures for surface mounting or on a cover plate for flush mounting. There is nothing finer in oiltight control stations—a sales asset on any machine.

Write today for Bulletin 800T.

HINGED COVER

The 9, 12, and 16-unit control stations have hinged covers. The hinge can easily be changed in the field from one side to the other.



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MOTOR CONTROL

QUALITY

Allen-Bradley Co., 1301 S. First St., Milwaukee 4, Wis.
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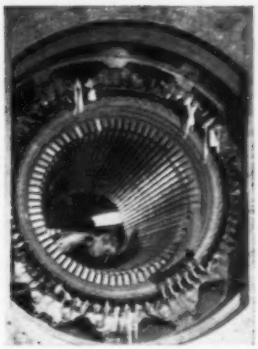

COVER: Both generators for the world's first 300-mw, 3600/1800-rpm close-coupled cross-compound steam turbine generator Unit #3 now being installed in the River Rouge station of the Detroit Edison Company have a new 540 degree coil transposition, newest development in stator coil transposition for large, deep slot stators. This arrangement minimizes eddy-current loss between strands caused by end flux as well as slot flux. The 1800-rpm generator is shown in Allis-Chalmers shops during coil installation. See article on page 133.

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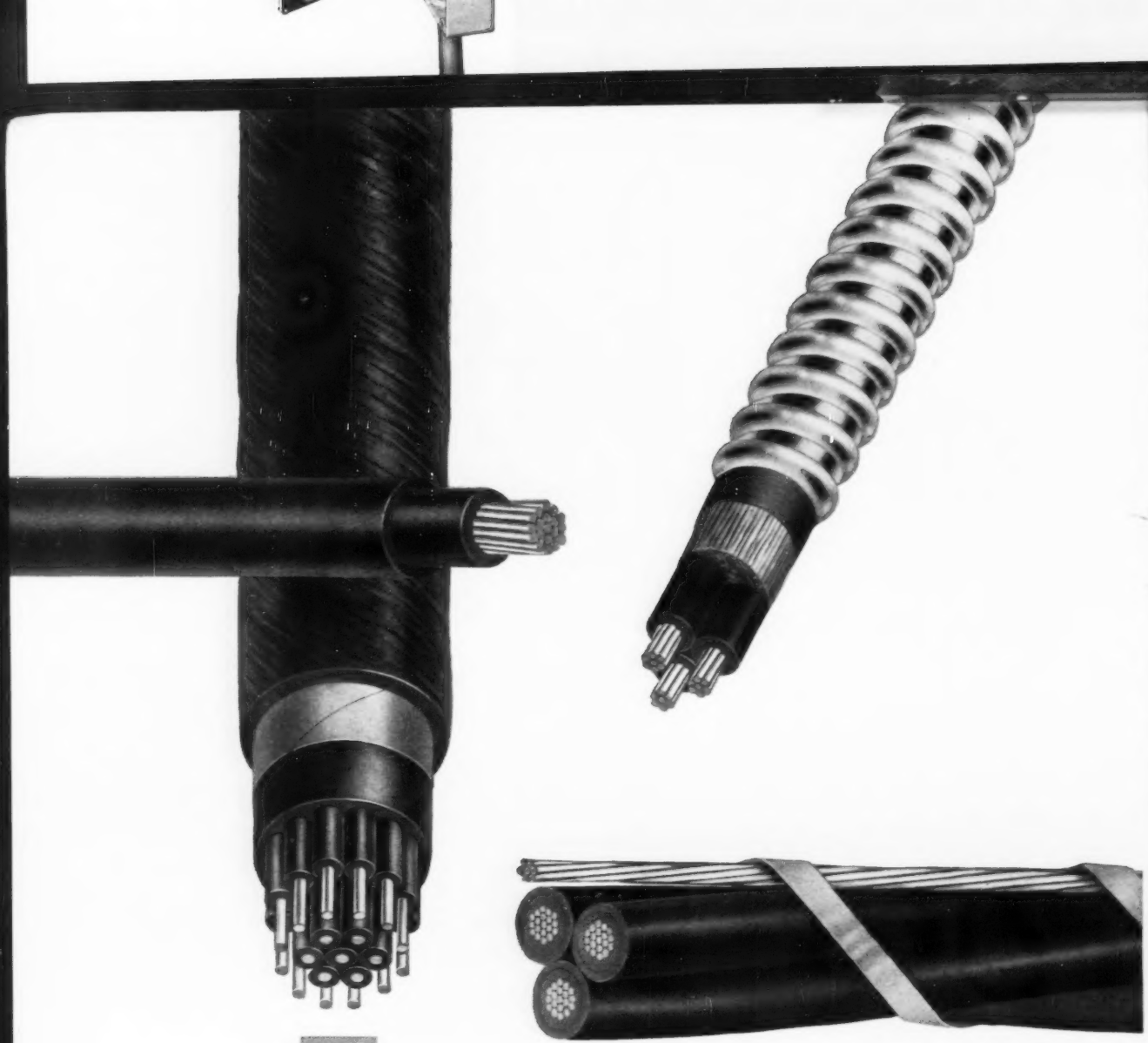

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it's the **KERITE** *that makes the difference*

For more information circle 1 on reader service card.

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he can switch your 12 kv feeders anywhere, any time, under any load with a hook stick using an S&C LOAD INTERRUPTER

The stick-operated S&C Alduti Load Interrupter in use

Sure! The switching of your 12 kv distribution feeders is getting tougher and tougher! Maybe your linemen are living with it, or maybe you are spending a fortune just to get by.

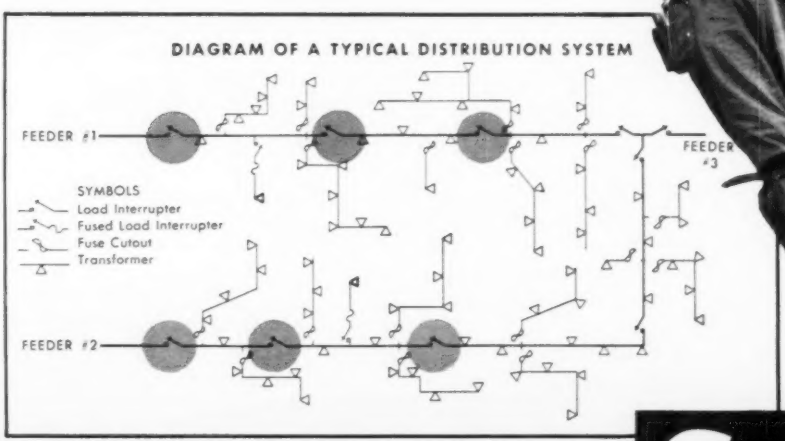
Is there another alternative?

Certainly! A stick-operated S&C Load Interrupter. It can switch positively—under any condition—any load, whether it's line charging current, capacitor charging current, magnetizing current, or full load. And it can be done without the hazards and uncertainties of an external arc. Here's a switch that will keep your linemen happy, and the comptroller, too.

USE IT AT SECTIONALIZING POINTS

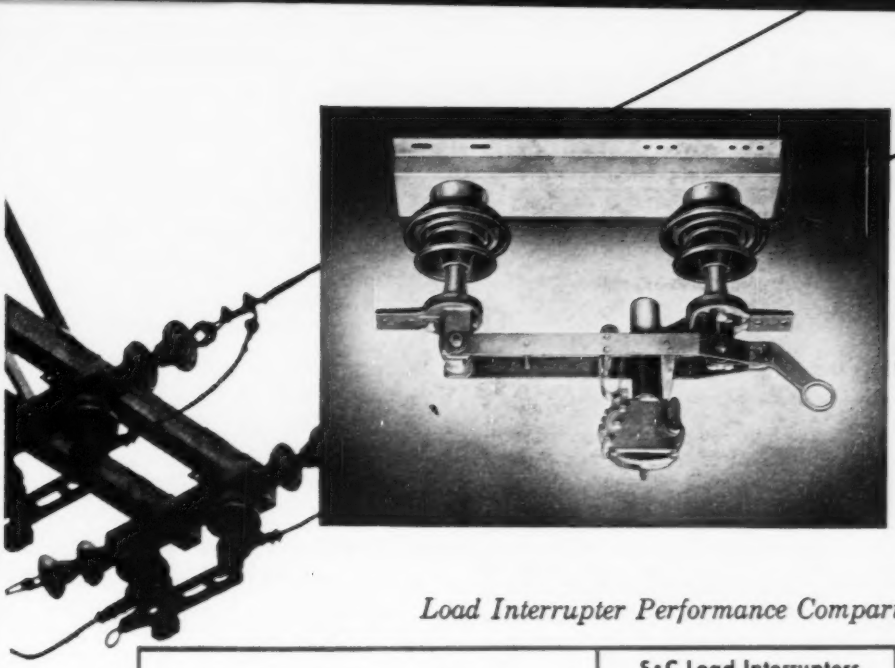
On 12 kv *radial* circuits, increased loads have made switching at sectionalizing points virtually impossible with conventional disconnects. On *loop* circuits (right) it's difficult enough where the duty involves only switching in parallel. And if the tie switches are open, hazard-free circuit interruption can be an impossibility.

Here, S&C Load Interrupters will give you safe, positive, circuit interruption on full line voltage and full load current—an advantage under emergency conditions, and a convenience under normal circumstances.



Specialists in High-Voltage Circuit Interruption since 1910

S&C



The S&C Load Interrupter, Alduti type; outdoor, single pole, (stick-operated); 14.4 kv, 600 amp. Three-pole, group-operated load interrupters are also available.

Load Interrupter Performance Comparison

PERFORMANCE	S&C Load Interrupters		Conventional Disconnects	
	Stick-Operated	Group-Operated	Stick-Operated	Group-Operated
Interrupt current from parallel sources safely?	YES	YES	DOUBTFUL	DOUBTFUL
Safe to equipment or personnel if inadvertently opened on full voltage (in case loop is open)?	YES	YES	NO	DOUBTFUL
Dump load without opening feeder breaker, or without preliminary unloading?	YES	YES	NO	DOUBTFUL
Multi-pole device controllable from ground (may be required by system practice or other circuits on same pole)?	NO	YES	NO	YES
Interrupt line charging current safely?	YES	YES	NO	DOUBTFUL
Cost?	LOW	HIGHEST	LOWEST	HIGH

The S&C Load Interrupter can switch the circuit without unloading preliminaries and without opening the breakers. The use of S&C Load Interrupters cannot lead to dangerous phase-to-phase or phase-to-ground faults, because there is NO EXTERNAL ARC. Also there is no danger to men or equipment in case of inadvertent operation. The S&C Load Interrupter breaks all load and charging currents instantly and decisively. Besides, you can mount it in any desired position —vertical, upright, or inverted. Write today for Catalog Section 760 on S&C Load Interrupters.

LOAD INTERRUPTERS

S&C ELECTRIC COMPANY

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POWER FUSES • DISTRIBUTION CUTOUTS AND FUSE LINKS • LOAD INTERRUPTERS • METALCLAD SWITCHGEAR

Why Shielding is Not Necessary for 5kv Okolite-Okoprene Cables

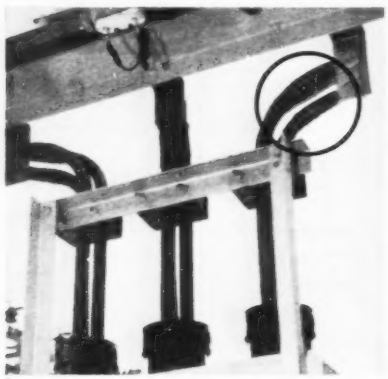
Here are the facts that will prove to you that non-shielded Okolite-Okoprene cables for 5kv service can—

- ***save you money***
- ***simplify splicing and terminating***
- ***eliminate grounding problems***

Old-Fashioned vs. Modern Practice

It is a fairly common practice for some engineers to follow convention by shielding all rubber-insulated cables for operation at over 3000 volts. Shielded cables, however, are expensive and to install them properly is a costly and time-consuming job. Considerable skill must be exercised to avoid having splices and terminations that will give trouble. Shielding that is improperly grounded offers a real hazard to human life.

It is not necessary to accept these higher costs and difficulties



Typical labor-saving application of non-shielded 5kv cable. Non-shielded cables like these save space, terminate like a 600-volt cable. Shielded cable would require extra cost of stress cone plus a longer unbent section.

for 3kv to 5kv installations because they can be eliminated by choosing properly designed non-shielded cable—such as Okolite-Okoprene—which can be handled as easily as 600 volt wire.

Modern Practice Backed by Over 20 Years' Experience

The advantages of unshielded rubber cables were first made available to the electrical industry in the mid 1930's when Okonite introduced the Okolite-Okoprene non-shielded construction for use up to 5kv. Nearly a quarter of a century of experience has proved the value and efficiency of this design which has since been adopted by many other manufacturers. Today, non-shielded cables are carried as standard stock items to meet the substantial demand for this type cable which users find reduces material costs, simplifies splicing and terminating, and eliminates grounding problems.

The non-shielded braided cables widely used 20 years ago frequently failed in damp locations because of discharge damage caused by the surface drainage of charging current arcing at points of casual contact with ground or an adjacent phase. Furthermore, the surface charges on braided cable presented a hazard to personnel. The National Electrical Code (Sect. 7107) has recognized this problem and does not permit the use of braided cables for service above 2kv in wet or damp locations unless they are shielded. Okolite-Okoprene non-shielded 5kv cables, using a new approach, solved this problem by eliminating the fibrous braid covering and replacing it with a carefully compounded neoprene sheath whose built-in dielectric qualities and inherent stability reduced drainage current to an insignificant minimum.

It requires a considerable degree of skill and experience on the part of the manufacturer to develop and produce a neoprene sheath of the necessary quality. Otherwise, the user will be forced into the costly alternative of purchasing shielded cable. E. I. duPont de Nemours and Co., Inc., the producers of basic neoprene have frequently stated that: "Too much stress cannot be laid on the important fact that the best neoprene products are produced by those manufacturers who are skilled in the art of compounding neoprene."

Certain cable specifications recommend shielding for neoprene-sheathed cables operating above 3000 volts. This requirement is intended to protect users from failures in cables having neoprene sheaths that do not possess proper electrical qualities. If such specifications called instead for a neoprene covering having stable electrical characteristics equal to an Okoprene sheath, this costly shielding requirement could be avoided to the obvious advantage of the user.

With the development of the Okoprene sheath, users obtained a premium quality 5000-volt cable that not only helped them to reduce costs but also helped them to eliminate the problems that are involved when using shielded cables.

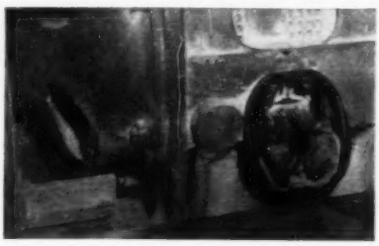
Correct Cable Design Key to Modern Practice

In designing this pioneer non-shielded cable, Okonite engineers included two essential components—a superior quality insulation and a dual purpose protective covering.

The insulation chosen was Okolite, an oil-base rubber compound, field-proved at voltages up to 35kv and possessing a high degree of heat and moisture resistance and stability as established in central stations, industrial plants and submarine circuits.

The covering was Okoprene, a rich neoprene compound specially formulated to provide excellent ozone resistance, high surface resistivity and high corona discharge level. Okoprene also possesses desirable mechanical features such as weather resistance, chemical resistance and ability to resist mechanical abuse.

The nation-wide acceptance of Okolite-Okoprene unshielded 5000-volt cables has been based on more



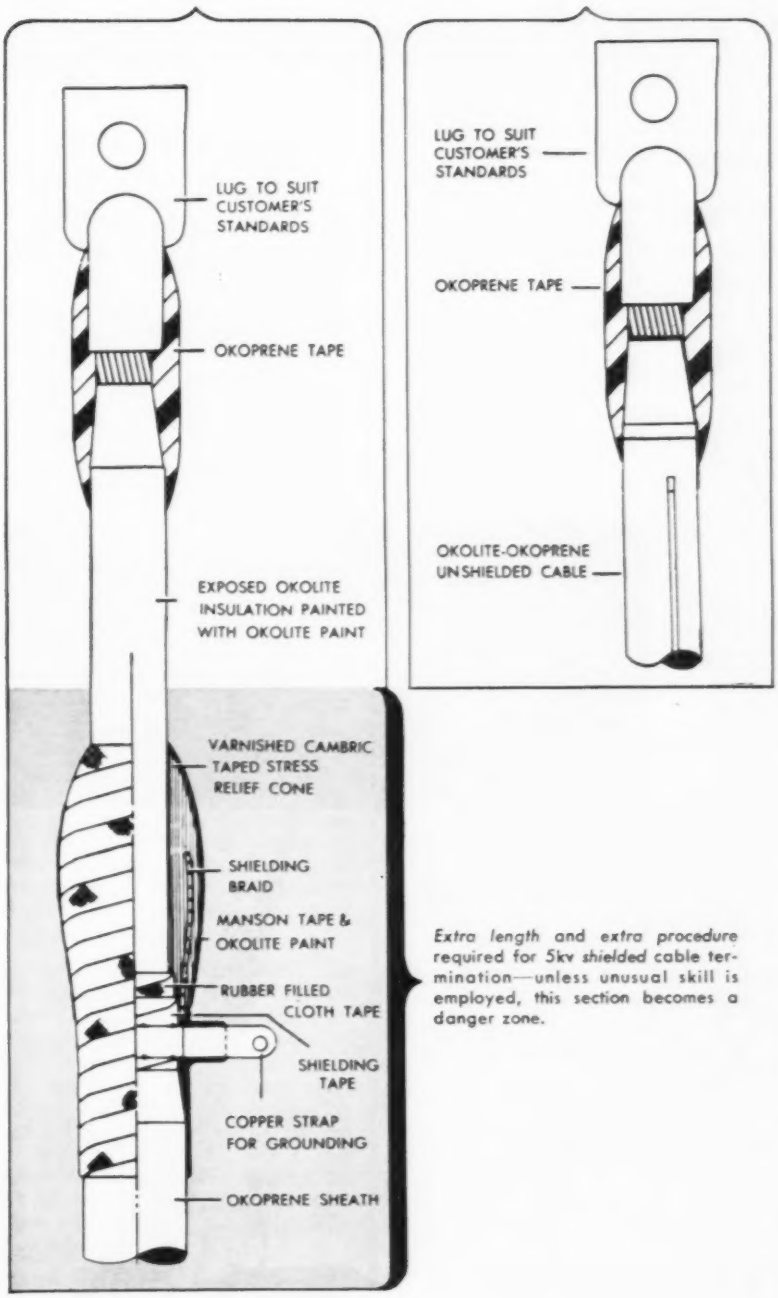
Typical terminal box for motor leads to 5000-volt motor. Standard boxes are a tight squeeze even for non-shielded cables. It is impossible to terminate shielded cables safely without providing a special box large enough to include the necessary stress cones.

For more information circle 3 on reader service card.

Compare the difficult termination of shielded cable with simple termination of unshielded cable.

a. Shielded 5kv cable requires time-consuming and long, complicated termination.

b. Non-shielded 5kv cable termination is simplicity itself, requiring minimum space.



Extra length and extra procedure required for 5kv shielded cable termination—unless unusual skill is employed, this section becomes a danger zone.

than 20 years of satisfactory field experience. During this period Okonite research and manufacturing activity has been devoted to further studies that will help to improve even this unequalled record. Okonite's policy is to foster developments that will provide cable users with greater values in economy, performance and reliability and to support efforts that will encourage, rather than restrict, advances in the art.

Unique Testing Procedure Confirms Cable Quality

In addition to the higher-than-normal industry high voltage a-c and d-c factory acceptance tests, the "Gooding Test Train" recently developed and used only by Okonite, provides additional safeguards for all cables insulated for operation over 2000 volts. This electronic testing equipment, which scans every inch of the completed Okolite-Okoprene cable, can pick out the most minute imperfections —impossible to detect by any other test method—that might shorten cable life after it has been placed in service.

This new and significant advance in high-voltage, non-destructive cable testing now allows Okonite to supply 5kv non-shielded Okolite-Okoprene cables that are even more reliable than their exceptional service record indicates.

The Economics of Shielded vs. Non-Shielded Cable

There is no question that non-shielded cable can be installed at considerably less cost than shielded cable. A comparison of the cable terminations shown here clearly demonstrates the simplicity of non-shielded cable terminals. No special training is required and splices, too, are easy to make. Splices and terminations for a typical shielded cable installation take 2½ to 4 times as long as for a non-shielded 5kv rubber-insulated neoprene-sheathed cable.

For complete information on Okolite-Okoprene unshielded cable, write for a free copy of Okonite's 128-page bulletin EG-1085 to The Okonite Company, Passaic, New Jersey.

where there's electrical power . . . there's **OKONITE CABLE**

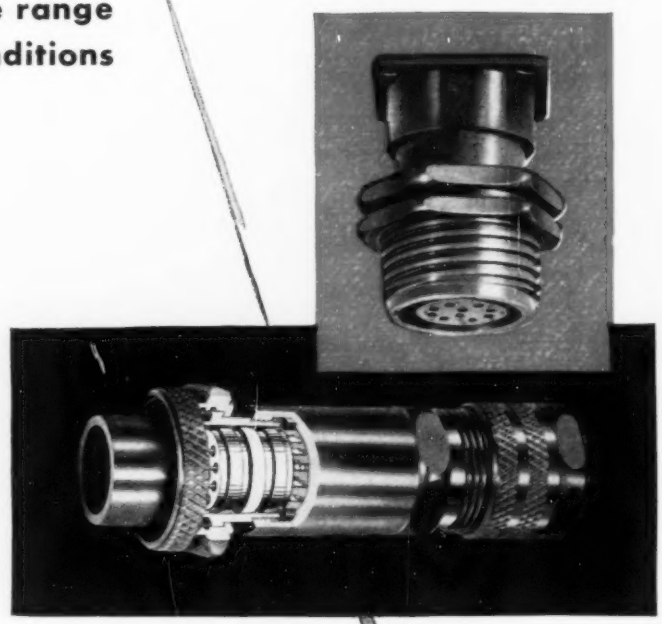
5782

PYLE *star-line*® CONNECTORS

Assure long-lasting protection of vital connections under a wide range of extreme environmental conditions

Currently establishing itself as a performance leader in the missile systems field, Pyle-Star-Line connectors offer engineers an entirely new line of electrical connectors for universal military and industrial use.

With characteristics of construction and performance never before combined in compact, rugged, lightweight standardized connectors, they exceed NEC requirements and classes A, B, C and E of military specifications MIL C-5015C.



FEATURES

Tough, lightweight shell: Strength comparable to mild steel, yet weighs only ⅓ as much.

Anodic coating: Gives shell toughness of case-hardened steel. Takes up to 1800 volts to penetrate coating.

"Sandwich" insulation: Silicone laminate floats between two rigid discs. Silicone disc absorbs shock, lets contacts align themselves freely; rigid discs impart just the right amount of restraint. Gives all advantages of both flexible and rigid mountings.

Chamber sealing: Silicone insulation disc positively and completely prevents water, gas, moisture or dust from passing into shell.

Wide range of pin and socket configurations: Configurations from 2 to 100 poles available. Within each form size all inserts are interchangeable and reversible.

Environmental Limits of Pyle-Star-Line connectors	
Temperature	—80 F. to 225 F.
Pressure	300 PSI External, 200 PSI Internal
Chemical Resistance	Most acids, most alkalis, oil
Corrosion Resistance	Salt Spray: 300 days without failure
Dust Resistance	Exceed requirements of MIL C-5015C
Shock Resistance	50G Minimum
Vibration	Exceed 20G to Method II of Mil C-5015C
Humidity & Moisture Resistance	Exceed Class E. Spec. of Mil C-5015C
Air Leakage	Meet Class E Spec. of Mil C-5015C

Write today for complete specifications.

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CONDUIT FITTINGS • CIRCUIT CONTROLS • LIGHTING EQUIPMENT

For more information circle 4 on reader service card.

Today more than yesterday... tomorrow more than today

A dependable source of stable voltage

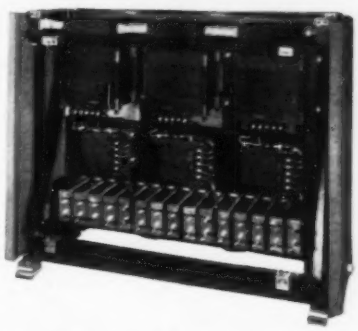
Today more than yesterday—and tomorrow more than today—circuit reliability and simplification is a vital responsibility of the electronic and electrical design engineer. Where the problem is voltage control, utmost simplicity and reliability is provided by the Sola Constant Voltage Transformer.

STANDARD-TYPE DESIGN *for the 250-1000 va ratings range of Sola Constant Voltage Transformers shows compactness and simplicity of this static-magnetic regulator.*

Along with its simplicity, the static-magnetic Sola regulator offers many important advantages over other voltage stabilizers, some of which depend upon saturation of core materials for their regulating action; or other types employing tubes. The performance characteristics of Sola Constant Voltage Transformers have led to their widespread use in applications for which other types of regulators are unsatisfactory. Included are:

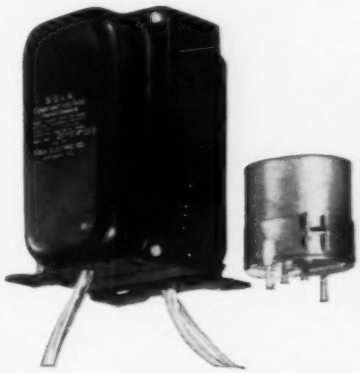
1. *Completely automatic, continuous regulation of output within ±1% with primary voltage variations as great as ±15%.*
2. *Response time of 1.5 cycles or less.*
3. *No moving or expendable parts or manual adjustments.*
4. *Self-protecting against short circuits or heavy overloads on output or load circuit.*
5. *Current-limiting characteristic protects load equipment from excessive fault currents.*
6. *Availability of transformation ratio for step-up, step down, plate and/or filament supply permits substitution in place of conventional non-regulating transformers.*
7. *Provides isolation between input and output circuits, often eliminating the need for "static shields."*
8. *Relatively compact compared to other equipment for comparable ac voltage regulation.*

The basic-design Sola regulator—referred to as the Standard-Type Constant Voltage Transformer — is available from stock in capacities from 15 va to 10 kva in a variety of ratings. Many of these standard models can also be supplied for 25 and 50 cycle service, or with other input and output voltages, on a "build-to-order" basis.



SPECIAL DESIGN *above exemplifies adaptability of the basic Sola Constant Voltage Principle to special electrical or mechanical needs. This unit, rated at 9 kva — either single, or three-phase — delivers ±1% voltage regulation with negligible harmonic distortion.*

Special adaptations of the basic design have resulted in six additional types of Sola regulators that meet a variety of voltage stabilization problems. Included are types that provide low harmonics in the output wave, regulation of electronic plate and filament voltage supplies, and lower-cost regulation for household appliance service.



LATEST ADDITION *are these filament-voltage regulators in capacities up to 25a at 6.3v. Capacitor, at right, is wired separately from transformer for most compact mounting of the assembly as component in manufacturers' product.*

Your letterhead request for "The Sola Constant Voltage Transformer —Theory of Design and Operation" will bring answers to your technical questions about the operation of the Sola regulator. This monograph includes a discussion of special adaptations of the basic-design voltage regulator. Specific information about transformer availabilities for your particular "component" or "end use" applications may be obtained promptly from your nearest district sales engineer. He's listed below.

SOLA *Constant Voltage* **TRANSFORMERS**

CONSTANT VOLTAGE TRANSFORMERS • LIGHTING TRANSFORMERS • CONSTANT VOLTAGE DC POWER SUPPLIES
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Sola Electric (Canada) Ltd., Toronto 17, Ontario: 102 Laird Drive, Mayfair 4554

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Spaulding PRODUCTS

FOR

Long Wear

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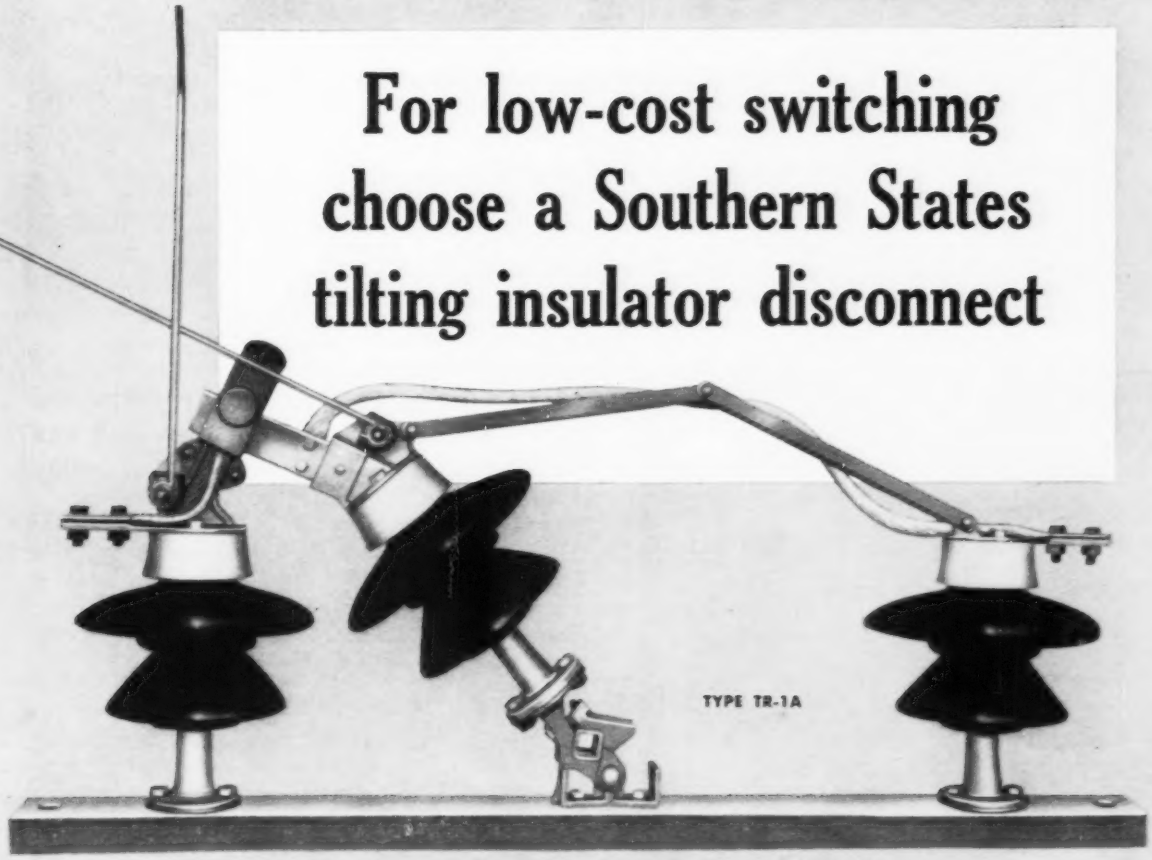

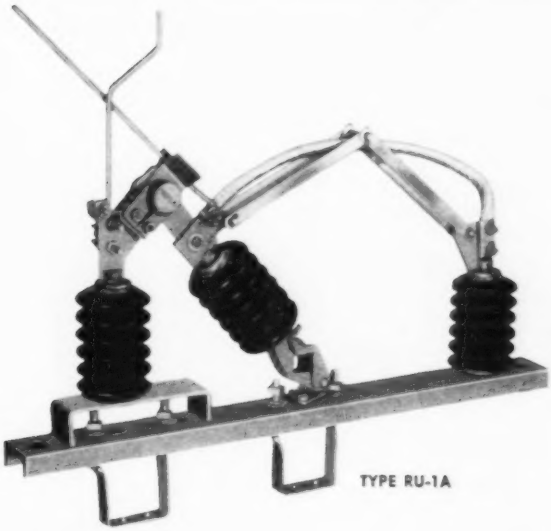

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Both types are ruggedly constructed, and will provide reliable switching under all service conditions. Many utilities throughout the nation have found in these switches the answer to their needs for low-cost, easily installed disconnecting switches. So can you. Get full details in our Bulletins 54 RU and 3050.

EASY INSTALLATION

One reason utilities find the installation of these switches so easy is the method for affixing the interphase shaft to the rocking insulator. The shaft is laid in its proper position across all three phases and then only one bolt per phase is tightened to complete the installation, saving valuable installation time in the field.

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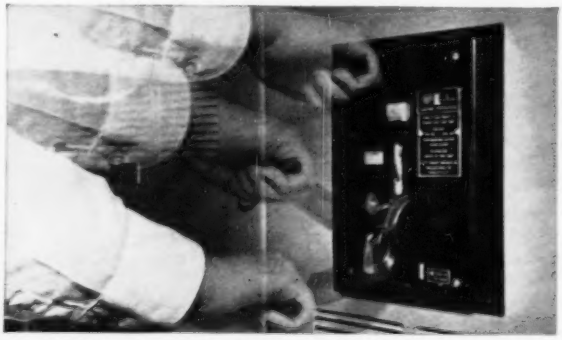
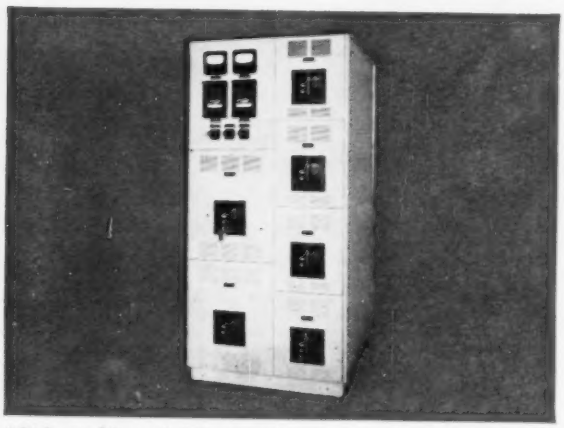
I-T-E makes sweeping design advances in new low voltage power circuit breakers, switchgear

I-T-E's new K-Line offers better performance, greatly simplified operation and servicing, and standardization in construction and assembly

Now we offer a complete new design of equipment for the switching, control and protection of motor, generator, transformer and feeder circuits, as well as other large electrically powered facilities—the most sweeping design advance in 13 years. Among the major innovations in the new design are the following.

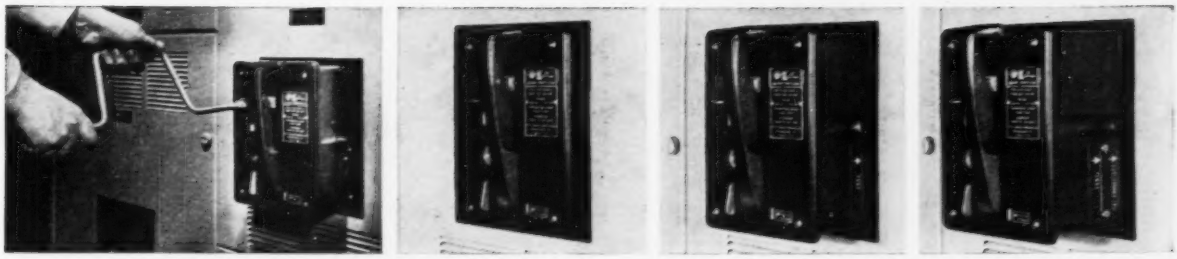


First quick-make manually charged stored energy closing mechanism. First 90% of pulldown handle travel charges spring mechanism, last 10% releases stored energy, automatically closes contacts. No teasing of contacts is possible.



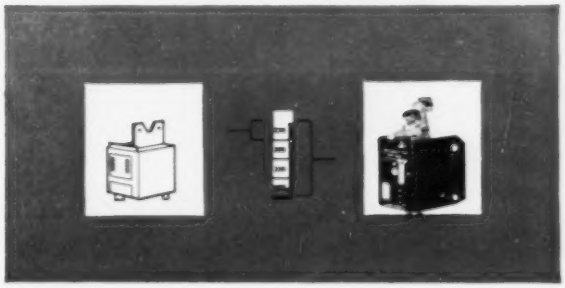
4-high stacking of 600 amp frame size circuit breakers in 90-in.-high enclosures. The new circuit breakers are as much as one-third smaller and 55% lighter than comparable units. The new switchgear is the smallest ever designed.

For more information circle 8 on reader service card.

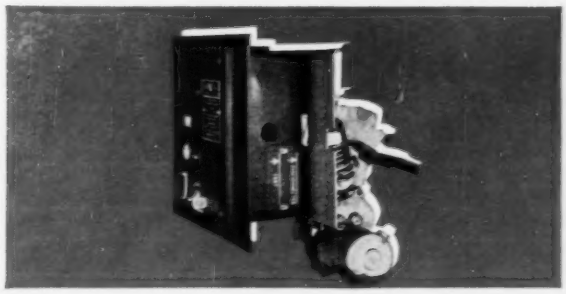


First closed-door drawout of circuit breakers. This permits racking of circuit breaker into connected, test and disconnected positions without opening the door of the circuit breaker compartment. Drawout arrangement keeps circuit breakers clean, aisles uncluttered, promotes personnel safety. Breaker must be opened before shutter can be lifted to insert drawout racking crank. Breaker cannot be closed while shutter is lifted.

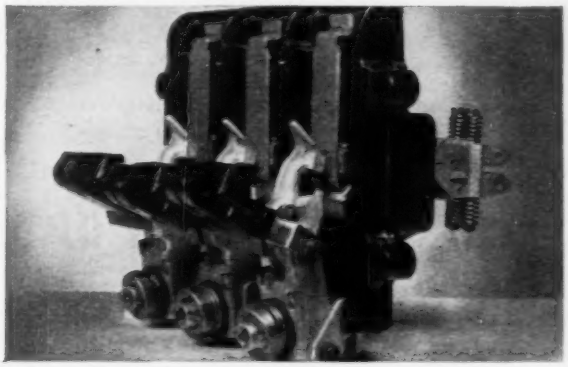
Greatly increased accessibility to component parts for operation and servicing. For example, trips on electrically and manually operated breakers are out in the open and can be easily adjusted. Trips also can be changed quickly. One-piece molding holds trip units, which are changed from the rear and in a fraction of the time formerly required.



Expanded trip flexibility meets last-minute load changes in many instances with the existing trip unit.



Stored energy electrical closure that materially cuts control circuit requirements. The motor-driven stored energy system requires only 10 amp from a simple power source, compared to as much as 160 by comparable solenoids. Quick-make manual closure operates on same principle. First 90% of pull-down handle travel charges a spring mechanism. Last 10% releases the stored energy and closes the contacts. No teasing.



Subassembly circuit breaker construction permits easier, faster replacement of parts. Six major subassemblies replace 130 separate parts in previous models. A part replacement formerly requiring an all-day overhaul of the circuit breaker may mean only removing and replacing a unit subassembly—a matter of minutes.

Bulletin 6004C tells the complete story of this advanced design switchgear. Ask your local I-T-E representative for a copy today. Or write I-T-E CIRCUIT BREAKER COMPANY, Switchgear Division, 19th & Hamilton Sts., Philadelphia 30, Pa.

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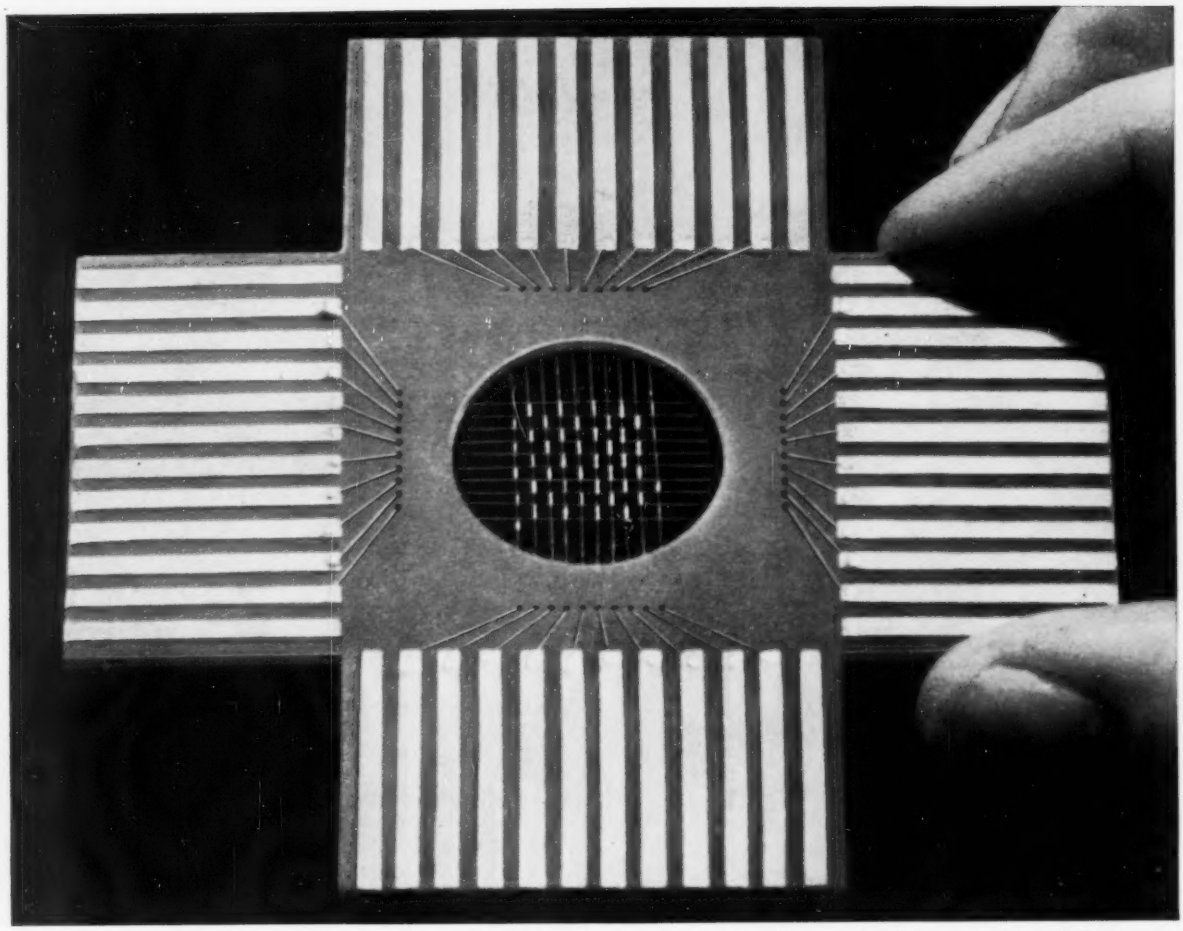

Model (simplified) illustrates basic structure of magnetic "Twistor" memory—magnetic and copper wires interwoven as in a window screen. Twisted condition of the magnetic wire shifts preferred direction of magnetization from a longitudinal to a helical path. One inch of twisted wire, thinner than a hair, can store as much information as ten ferrite rings. "Twistor" was invented at Bell Laboratories by Andrew Bobeck, M.S. in E.E. from Purdue University.

New twist in memory devices

An ingenious new kind of magnetic memory has been developed by Bell Laboratories scientists for the storage of digital information. Known as the "Twistor," it consists basically of copper wires interwoven with magnetic wires to form a grid.

"Twistor" gets its name from a characteristic of wire made of magnetic material. Torsion applied to such a wire shifts the preferred direction of magnetization from a longitudinal to a helical path. This helical magnetization has been applied to produce a magnetic storage device of unprecedented capacity for its size.

In a magnetic memory, information is stored by magnetizing a storage element. In conventional memories the storage elements consist of rings of ferrite. In the "Twistor," they consist of tiny segments of hair-thin magnetic wire. At each intersection of the grid, one such segment is capable of storing a binary digit.

The "Twistor" is simple and economical to fabricate, and its minute energy requirements are easily supplied by transistor circuits. Bell Laboratories engineers see important uses for it in future telephone systems which demand the compact storage of much information, as well as in digital computers for civilian and military applications.

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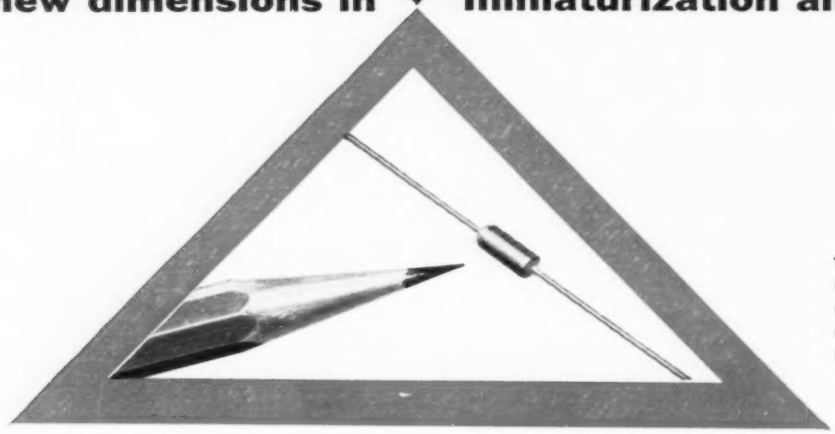

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Thermal coefficient of these capacitors is sufficiently low and linear so that for the first time a circuit designer can think of an electrolytic in terms of parts per million capacitance change. Nominal value is +500 ppm/°C. The capacitor may be used without derating over a range from +85°C to as low as −80°C, a temperature at which no other electrolytic has proved useful.

Solid construction permits the Type 150D to withstand the severe shock and vibration encountered in missile and ballistic applications. Hermetic sealing makes it completely immune to humid atmospheric conditions.

Complete performance data covering the wide range of sizes and ratings are in Engineering Bulletin 3520B, available on letterhead request to the Technical Literature Section, Sprague Electric Company, 321 Marshall Street, North Adams, Mass.

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The Functional Plan

WALTER J. BARRETT
PRESIDENT AIEE
PRESIDENT UET

The functional plan for organization of the Engineering Profession is not a new plan. It has been referred to as the "AIEE Plan," the "Coover Plan," and the "San Francisco Plan." The purpose of this article is to clarify the intent of the plan and to remove certain misunderstandings which have arisen.

I HAVE BEEN amazed at how widespread seem to be certain misunderstandings about the action taken by the AIEE Board of Directors in San Francisco, Calif., in June 1956, and at the number of incorrect statements concerning it which have appeared in the press. The Board action referred to is the one regarding intersociety relations, which was reported to the Institute members in a letter from then President Coover presented in *Electrical Engineering*, June 1957, p. 516.

The purpose of this article will be to attempt to clarify the situation and to remove some of the misunderstandings.

To begin, let me meet some of the misstatements head-on by stating certain things which the AIEE Board action did not do.

1. It did not propose that AIEE discontinue any of its interests, give up any of its activities, or put an end to any of the types of services it has been performing on behalf of its members, including students.

2. In proposing some realignment of responsibilities as among Engineers Joint Council (EJC), Engineers' Council for Professional Development (ECPD), and National Society of Professional Engineers (NSPE), it did not impose any condition whatever. For instance, it did not specify as a condition of this realignment that NSPE should open its membership rolls to nonregistered engineers.

3. It did not propose that NSPE become a constituent society of either EJC or ECPD.

4. It did not propose that EJC and ECPD combine.

5. It took no position with regard to the establishment or nonestablishment in the immediate future of an over-all unity organization for the engineering profession.

Now that we have seen some of the things which the AIEE Board action did not do, let us turn to the positive side and examine just what this action did propose.

Having observed the functioning of the various organizations in the engineering profession for a long time, and having discussed the problem of how the profession should best be organized, not once, but at practically every one of its meetings for several years, the Board on June 28 in San Francisco spent considerable time, as a "Committee of the Whole," discussing the matter in some detail. One thing which had been a cause of concern to the Board was the overlapping of certain of the activities of EJC with those of ECPD and of NSPE. Such duplication was considered highly undesirable, because it could lead to confusion and a loss of effectiveness. The conclusions reached by the Committee of the Whole were summarized in four recommendations. Immediately upon reconvening, the Board of Directors took action on these four items. I think it will be well to quote the four Board actions and discuss each of them briefly. The Board

1. "VOTED to adopt in principle, and actually to support, three organizations of a character approximating the present EJC, ECPD, and NSPE with certain

Walter J. Barrett is with New Jersey Bell Telephone Company, Newark, N. J.

functional modifications (as recommended by the Committee of the Whole) as currently most suitable to serve the over-all needs of the engineering profession.

2. "VOTED to request the President to appoint a special committee to draft, subject to Board approval, a statement to the membership and other interested parties, setting forth the proposed AIEE position on intersociety relations as recommended by the Committee of the Whole.
3. "VOTED to request the President to appoint a committee with instructions to approach NSPE with the suggestion that its membership be opened, for a period of years, to unregistered engineers holding suitable grades in technical societies subscribing to ECPD uniform membership grade standards.
4. "VOTED to rescind the instructions to AIEE representatives on the EJC Board of Directors to work for the development of EJC into an individual membership type of unity organization."

MODIFICATIONS

THE FUNCTIONAL MODIFICATIONS referred to in action 1 provided that EJC would relinquish the activities it was then conducting in the fields of employment conditions, labor legislation, practice of engineering (code), social security legislation, and certain kinds of special surveys (the more recently initiated activity in engineering education would likewise be considered inappropriate); that ECPD would relinquish its interest in the practice of engineering (code); and that NSPE would relinquish its activities in the fields of technical education and young engineers.

Engineers Joint Council would function primarily as a co-ordinating body for technical matters crossing the boundaries of the various disciplines. It would retain its interest in the recognition of specialties, honors for engineers, the National Engineers Register, and relations with corresponding bodies in foreign countries. This is the "technical" group of activities.

Engineers' Council for Professional Development would continue its interest in the education and development of young engineers, the establishment of standards for engineering education, the accreditation of engineering curricula, and the canons of ethics. This is the "educational" group of activities.

National Society of Professional Engineers would continue its activities relating to registration of engineers and economic considerations in the employment of engineers, including salaries and fees. It alone would be responsible for formulating rules of behavior under the ECPD canons of ethics and for discipline under these rules. It would continue its activities in national affairs and national defense and would be the sole spokesman for the profession in matters of legislation affecting engineers. It would be responsible for public relations to enhance the prestige and standing of the engineering profession as a whole. (The technical societies would, of course, be free to conduct such public relations activities as they consider appropriate in their own specific fields.) The activities allocated to NSPE are those in the "professional" group.

With regard to surveys of the profession, it was the consensus that when the subject matter is technical, surveys by EJC or a similar technical co-ordinating body are proper. When the subject to be surveyed is political or has to do with economic welfare and working conditions of engineers, it was considered to be more properly the function of a body of the type of NSPE.

NO CHANGE IN AIEE

IT WILL BE NOTED that the subject under consideration by the Board of Directors, and upon which it acted, related to the functioning of EJC, ECPD, and NSPE. There was no proposal that AIEE should discontinue any of its interests or activities or any of the services which it customarily has been giving to its members, including students. EJC and ECPD are joint agencies established by the individual membership engineering societies to carry out jointly on behalf of the members of those societies certain functions which are of broad interest to the entire profession and which can be more effectively handled in this manner. AIEE, in working through such joint agencies, does not relinquish any of its interest in or responsibility for the subject matter. Such joint agencies are composed of representatives of the various societies acting for the societies they represent, not independently of them.

Because of the variation in conditions affecting engineers in the various disciplines, it is contemplated that the engineering societies will continue to maintain committees on such matters as education, registration, professional conduct, etc., for liaison with EJC, ECPD, or NSPE, as the case may be, to insure that those groups are kept informed as to the particular viewpoints of the members of the various societies.

There can be no question but that AIEE will continue to need an Education Committee, for example, to keep alert and up to date on problems and needs in electrical engineering education, in order to interpret these to ECPD and assist ECPD in the establishment of policies and criteria pertaining thereto. In the field of any learned profession, there is no person or group of persons qualified to establish standards of education, competence to practice, ethics, etc., except the members of that profession. It is, therefore, the responsibility of the organization of the members of that profession to concern itself with these matters. AIEE is the organization of the members of the profession of electrical engineering, and, therefore, *is* the profession of electrical engineering. Its responsibility is inescapable. The fact that certain of its members who are engaged in the education of electrical engineering students may be members of certain committees of ECPD, or members of the American Society for Engineering Education (ASEE), or both, is a mere coincidence. The responsibility for standards of education in the field of electrical engineering rests with the profession as a whole.

It is appropriate and convenient that it join forces with other branches of the engineering profession in setting up a joint agency for efficiently carrying out its responsibility, under guidance, but this does not relieve it of the responsibility.

The special committee provided for in action 2 of the Board was appointed. It prepared a statement which, after study and revision by the Board, appeared in the form of the letter referred to previously.

It will be noted that action 3 provided for a *suggestion* to be made to NSPE, and did not impose this as a condition related to action 1. During subsequent meetings of the Board of Directors, it was decided that if NSPE would accept this suggestion, the AIEE Board would urge all of its members to affiliate with NSPE. This appears in the letter to the membership.

Action 4 related to long-standing instructions to our representatives on the board of directors of EJC. When the proposal to enlarge EJC was adopted by the engineering societies as a result of the work of the exploratory group on unity of the profession, AIEE imposed upon EJC the obligation to give prompt consideration to converting itself from a joint body of representatives to an individual membership organization. This was considered by EJC, but the decision was in the negative. Under the functional plan for division of activities among EJC, ECPD, and NSPE, there would be no advantage in making EJC an individual membership organization.

REGISTRATION

THE SUCCESS of the functional plan and the strength of the organized profession obviously will be greater as more and more engineers who are members of a technical society also join NSPE. AIEE has, for many years, recommended to its members that they take steps to register as professional engineers. The Board of Directors believes that this is an essential step in the full development of the practicing engineer, whether he be a consultant or employed in industry. We urge all young engineers to register in their states as early in their careers as possible. If this advice is followed by members of all the technical societies, it is obvious that the time will come when the same people who make up those societies will be the members of NSPE or at least eligible for membership in NSPE. It is believed that NSPE can put itself immediately in a much stronger position to carry out the responsibilities proposed for it by the functional plan if, for a period of years, it will open its membership to nonregistered engineers who are otherwise qualified as evidenced by their holding suitable grades of membership in technical societies which subscribe to ECPD uniform membership grade standards. This is the reason for making this *suggestion* to NSPE as an interim measure and offering, if it is accepted, to urge all of our members, both registered and nonregistered, to join NSPE.

ONE SOCIETY?

IF, EVENTUALLY, it appears desirable to amalgamate all of the various societies into one unity organization for engineers, AIEE believes that the adoption of the functional plan will facilitate this end. AIEE is not at this time taking a stand for or against such eventual amalgamation. However, even without such eventual amalgamation, we believe that the functional plan would be a big step forward in the organization of the profession, and would permit, indeed would promote, more effective performance. It is recognized that there are certain practical obstacles in the way of establishing an over-all unity organization at the present time. To mention but one: The American Medical Association and the American Bar Association are classified by the Director of Internal Revenue under paragraph 501(c)6. Undoubtedly, an over-all engineering unity organization would be similarly classified. The individual membership engineering societies today, other than NSPE, are classified under paragraph 501(c)3. These societies are embarked upon a plan for raising funds for the erection of a new $10 million United Engineering Center fronting on United Nations Plaza in New York City. Contributions to organizations classified 501(c)3 are deductible to the donor for tax purposes; contributions to organizations classified in 501(c)6 are not.

If we could have the clear-cut nonconflicting functional organization contemplated in San Francisco and if, in addition, all the eligible members of the technical societies were also members of NSPE, we would have an organization of the profession which would indeed be strong. Certain of the other engineering societies have been favorably impressed by the functional plan and have taken steps to call it to the attention of their members. It is to be hoped that the other societies will take parallel action and that the plan may receive the positive endorsement of all groups.

Just before this article was sent to the editor, it was learned that the Council of the American Society of Mechanical Engineers (ASME), meeting on November 30, 1957, approved the recommendation of their Organization Committee ". . . that ASME endorse the 'AIEE plan,' as outlined in M. S. Coover's March 18, 1957, letter to President Ryan." The Council also indicated its willingness to explore the plan with the organizations involved. This is indeed good news. It is most heartening to find ASME and AIEE, two of the largest segments of the engineering profession, in agreement regarding what seems to be the most constructive proposal yet advanced for straightening out the somewhat tangled organization of the profession.

Illustrative of the need for clarification are the actions of AIEE and some other societies in approving the proposed affiliation of NSPE with ECPD, and the recommendations by certain societies that NSPE join EJC. These relationships were not contemplated by the AIEE Board at San Francisco and would seem to be inconsistent with the proposed separation of the fields of interest.

Training Operating Personnel for Nuclear Power Plants

W. G. McKEOWN

A sound approach to the assurance of safe nuclear power plant operation consists both of the use of thoroughly trained operating personnel and the provision of adequate reactor control systems. A description is given of several of the important operating positions in a nuclear plant, and methods of training and evaluating personnel for these important jobs.

HISTORY will probably view the development of the nuclear power plant as the most important factor in the growth of the atomic age. However, public opinion still links many applications of nuclear energy with its first disclosure—the bomb. This was recently demonstrated by the vehement objection to the construction of a nuclear power plant in Michigan by organized groups in the surrounding territory. To counteract such reaction, it is essential that nuclear power plants continue to be operated safely.

To assure safe operation, the reactor control circuits contain safety features that are designed to protect the plant in the event of equipment failure or of operator error. Relying solely on these safety features is not good operational practice. A sounder approach is to train all operating personnel thoroughly and to indoctrinate them in their duties and responsibilities for safe operation. The safe operation of a nuclear reactor should depend primarily upon the administrative control and operation, and secondarily upon the designed shutdown control systems. For obvious reasons, neither can be eliminated.

Because the nuclear power plant is new and differs from the conventional plant, special training of personnel is necessary. The reactor as a heat source and its method of control are unlike the normal fuel supply. Special equipment, components, and materials designed especially for nuclear industry have unique features. High-integrity leakproof piping and components guard against contamination from radioactive material. Aside from the physical plant and its operation, personnel must understand the inherent occupational hazards. It is extremely important that personnel learn the radiological hazards, the methods of protection, and their responsibility in preventing overexposure and injury. In addition, there is a jargon peculiar to the nuclear plant. Such words as scram, crud, bubble, and meat are strange terms to the operators of a conventional power plant.

The supply of experienced personnel in the nuclear power industry is very limited, and the possibility of an organization acquiring a staff of trained people is remote. Although nuclear power plants may differ in some aspects as they develop, the pioneer power producers will serve as a pattern for organizing operating forces, and can provide valuable assistance in training operating personnel for future plants. A brief description of a typical nuclear power plant will aid in explaining a comprehensive training program for operating personnel.

Nuclear power plants in the present stage of development can be divided basically into two systems: the primary and the secondary. The primary system contains the reactor, the reactor vessel, piping, heat exchangers, coolant pumps, and the necessary auxiliary systems, equipment, and controls. The secondary system includes steam generating units, steam headers, turbines, condensers, generators, associated controls and switchgear, and, in general, components similar to those of the conventional steam plant. The basic difference between the nuclear plant and the conventional plant is the heat source and the heat transfer method in the primary system.

Plant layout may vary from one project to another, but two distinct areas will be found in every nuclear plant: an accessible area which may be occupied at all times, and an inaccessible area which may not be occupied during the plant operation because of radiation levels. One plant in operation today has the accessible area subdivided into the upper half of the reactor compartment and an engine room. The inaccessible area is the lower half of the reactor compartment which contains equipment and components located in high radiation fields.

The accessible area of the reactor compartment is shielded to permit access to the primary system, auxiliary systems, and portions of the secondary system located in this area. The engine room contains the turbines and associated equipment. Another accessible area is the control room in which panels for operating and monitoring the entire operation are located. Fig. 1 is a simplified sketch showing compartments and components.

ORGANIZATION

PLANT OPERATORS, classified according to their work areas, include the reactor compartment operators, the

Full text of a conference paper presented at the AIEE Pacific General Meeting, Pasco, Wash., Aug. 28-30, 1957, at a session on nucleonics.

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engine room operators, and the panel operators. In the control room, there is an operator each for the steam section panel, the electrical section panel, and the reactor section panel.

The reactor compartment operator is responsible for the proper operation of the primary system, auxiliary systems, and parts of the secondary system located in the accessible area of the reactor compartment. He, or the reactor section panel operator, has selective control of equipment in the inaccessible area which can be controlled remotely.

The engine room operators are responsible for the local operation of turbines, condensers, circulating water systems, and lubricating oil systems. They are also responsible for all the equipment associated with the secondary system.

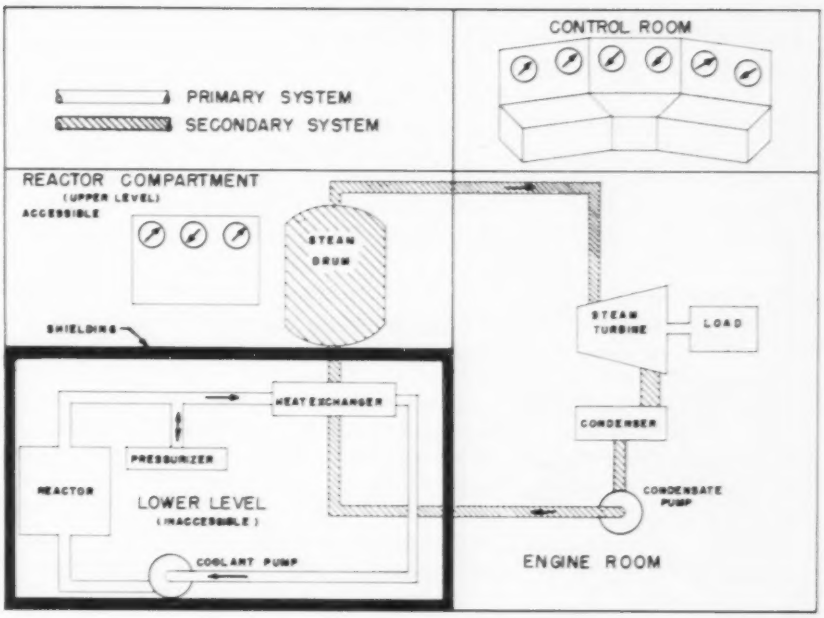

Fig. 1. Compartments and components of a nuclear power plant.

The steam section panel operator monitors the steam system operation and operates equipment remotely controlled from this panel. The electrical section panel operator performs all switching operations and controls the electrical output of the plant.

The reactor section panel operator primarily controls the reactor. By movement of the control rods, the reactor temperature is varied to compensate for load changes. The reactor section panel operator also has remote control of primary system valves and auxiliary systems which are vital to the plant operation.

Co-ordinating the operation of the entire plant and observing safe proper procedures are the duties and responsibilities of the chief operator. He is required to have a very thorough working knowledge of the plant mechanics as well as the technical aspects of its operation.

A reactor expert, known as the reactor engineer, is required to observe that the reactor, its control systems, and its instrumentation are properly and safely functioning. He performs a staff function in the organization and must be technically able to evaluate and make recommendations concerning the operation of the reactor.

A supervisor with an engineering background and operating experience is responsible for the entire plant. In addition to the plant operators, the reactor engineer, and the chief operator, the supervisor is accountable on a shift basis for other dependent departments which affect the plant, such as chemistry, industrial hygiene, and maintenance. A typical shift organization is illustrated in Fig. 2.

OPERATOR TRAINING AND QUALIFICATION

The training and instruction of operating personnel is divided into two phases: academic (or classroom) and operational training. Since an organization will be composed of people with different educational backgrounds, the academic training must be flexible. Classes in reactor theory and kinetics, mathematics, physics, chemistry, industrial hygiene, and thermodynamics should be considered in a complete program. An extensive knowledge of reactor theory and control is desirable for the reactor operators, and is required for reactor engineers. Basic reactor theory is useful for all personnel to comprehend fully the operation of the plant. The economic expenditure of such instruction can be well justified by the improved quality of operators, the elevation of morale, and the enhancement of employer–employee relationships.

The operational training curriculum includes general knowledge of the over-all plant and its operation, and a specific knowledge of the particular station the operator is required to stand.

Classroom instruction can be used to excellent advantage in presenting the general plant and its operation. System description and function can be learned from schematic drawings or projections in group instruction. To co-ordinate the classroom work with the physical plant, the operators are expected to trace the actual systems and learn the physical location of the components. Integration of instruction and application by performing practical factors is the most advantageous method in the operational training phase.

A training guide was prepared to aid the operators in learning the specific stations. This guide includes the

curriculum or study plan arranged in a logical sequence. In following this plan, the operator must learn specific required facts pertinent to the systems, components, controls, or instrumentation for that station.

For example, in a hydraulic system, the operator is expected to trace the piping, and learn the location and function of valves, pumps, and other components. He is also expected to know the power supplies, instrumentation, normal and abnormal readings, and limita-

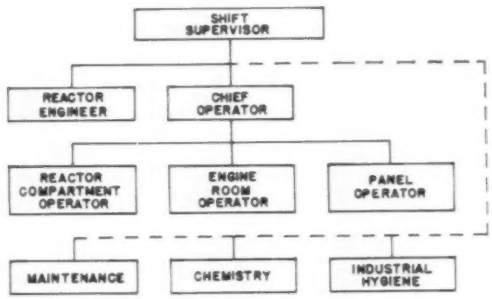

Fig. 2. Typical shift operation in a nuclear power plant.

tions; the proper manner to operate the equipment, and its interaction or effect on other systems; and the procedure to follow should a malfunction occur. Each system, either mechanical or electrical, relative to that station is included in the qualification requirements and must be learned. As an example, some items which may appear on a qualification check sheet for the reactor operator are as follows:

1. Demonstrate knowledge of the following:
   a. Basic reactor theory
   b. Reactor safety, hazards, and limitations
   c. Reactor control systems and circuits
   d. Nuclear instrumentation
   e. Rod control mechanism
   f. Scram and insertion protection
   g. Rod programming methods
   h. Alarms and indicating lights
   i. Operation of power supplies
   j. Radiation monitoring system
   k. Effects of poison buildup and burnout on reactor control
   l. Effects of plant operation on reactor control
   m. Operating and casualty procedures and safety precautions
2. Study training manuals for an operational knowledge of the entire plant.
3. Demonstrate proficiency in the following practical factors:
   a. Operation of non-nuclear portion of reactor section panel
   b. Operation of nuclear portion of reactor section panel
   c. Complete startup checkoffs
   d. Latch rods
   e. Operate the reactor from startup at source level to criticality
   f. Operate the reactor from criticality to power
   g. Operate the reactor at nonsteady-state conditions
   h. Transfer control between normal and automatic
   i. Perform rod configuration changes
   j. Shut down the reactor
   k. Complete shutdown checkoffs

As the trainee completes an item on the check sheet, the item is initialed by an instructor. The check sheet contains only the most obvious and important topics required for the operation station. To assure that the operator has the knowledge, skill, and competence required, he is examined by means of either an oral or a written test.

For the more responsible positions of reactor engineer and chief operator, the qualification requirements are more extensive.

The reactor engineer is not required to specialize on the steam plant equipment, but must understand the effects it has on the reactor and primary system. In addition to being an expert on the reactor, its controls, and its instrumentation in both a technical and an operational sense, he is required to be capable of performing tests to insure the functioning of all the reactor protective features. After completing the qualification requirements for this position, the reactor engineer must pass successfully a written and an oral examination given by a board of experienced and technically qualified personnel.

The qualification requirements for chief operator demand a comprehensive knowledge of the entire plant. Because he is responsible for the operation of the plant, he must have not only a thorough understanding of each station, but also a complete knowledge of the plant as a unit. As a result, the chief operator's qualifications are more extensive and require considerably more time and study. Essentially, the chief operator must qualify on every operating station in the plant. Successful completion of a written and an oral examination given by a board are also required for this position.

Reports on the training progress of each trainee are sent to management at regular intervals to assure satisfactory advancement and application.

TRAINING IN DEPENDENT FIELDS

To be qualified fully, operators also must be indoctrinated in various dependent fields. Foremost among these is industrial hygiene. The health and safety of each individual depend on his knowledge of radiation, its effects, methods of control, and his attitude to rules and procedures set up by this group. Upon employment, everyone must be indoctrinated in the hazards involved in the job and the methods used for protection. Explanation of the personnel metering devices to record the radiation dose and the individual's responsibility for proper use of this equipment is necessary. After the employee has become familiar with a plant, a more intensive program is in order. Biological effects of radiation, actual and potential hazards, techniques of radiation and contamination survey, control of contamination and decontamination methods, and air hazards and their control are important topics that are taught by this department. It is particularly important for people to realize the fact that radiation and contamination are imperceptible to the senses. Reliable instrumentation is a necessity not only for the control of the reactor, but also for personnel protection.

Training in reactor instrumentation and control is required for reactor engineers and operators responsible for the reactor operation. Like other components, instrumentation has been developed specifically for the nuclear power industry. Since the industry is new and much information is to be learned, initial plants will contain more instrumentation than necessary for ordinary operation, and much of it will be of precision quality. Instruments and methods for measuring reactor power level are of utmost importance to guarantee safe operation of the reactor. To check the power level further, calibration methods of comparing the steam plant output with the nuclear instrumentation are required. The extent of training in this field should be limited to recognition of equipment failure, field repair, and replacement with spare units. Extensive repair or trouble shooting is more efficiently performed by specialized departments.

An indoctrination in plant chemistry is specifically important to chief operators and supervisors. Understanding of the over-all plant operation must include the chemical specifications and their significance. The chemistry curriculum can be divided into the primary system, secondary system, and radiochemistry. Operating personnel should know the fundamentals of corrosion theory, corrosion monitoring and control, and the specifications for both the primary and secondary systems. Performance of specific tests are not required, but the significance of the results and the action required is important. Knowledge of the function of the radiochemistry department and its methods of monitoring the primary coolant purity is significant to correct plant operation.

Operating personnel should be familiar with maintenance problems and techniques. High radiation levels on primary system equipment may limit the time a workman can spend on a job without overexposure. Therefore, it is important to train several people for maintenance work. Unusual maintenance methods and procedures are often required for equipment specifically designed for the primary system. New construction materials, the degree of cleanliness, contamination, and radiation present additional unconventional problems. The secondary system maintenance is similar to the normal steam plant.

TRAINING AIDS

Sole use of the plant for training operators to become experienced with the operational complexities and problems will be at a premium if the plant is operated chiefly for power production. A tool for training operators is the training simulator. Its function is to present the plant operating conditions as seen by the operators at the control panels. Such a simulator console includes a functional layout of the main components and controls of the plant with emphasis on the reactor operation. Simulation of the plant behavior and effects of action by the operators is observed from instrumentation and annunciator equipment. Operation of the simulator provides useful and versatile training without subjecting the plant to inexperienced operators and additional wear and tear.

Instruction manuals have been found to be the most satisfactory method of presenting plant information to operators. Schematic diagrams of plant systems with written descriptions and explanations of the operation and control help the operator learn, and also serve as a valuable reference. Compiled facts and figures on the equipment are readily available without searching many engineering prints or manufacturers' instruction books.

Training aids in the form of models and sectionalized components of equipment peculiar to the primary system are valuable. Such aids are helpful in learning the construction and operation of equipment and also can be useful in planning maintenance. Because of radiation levels, planned approaches and trial runs can be made on models or mock-ups to gain experience, and thus save manpower and minimize exposure.

One of the most useful training aids is 2- by 2-inch slides made from 35-mm color film. Color-coded pipes and lines and stenciled components are clearly illustrated, and give the operators a very good display. This is especially important since the inaccessible area of the reactor compartment cannot be entered during critical operation.

Entrusting operating methods and procedures to memory and to the individual personality of operators cannot be tolerated. Clear, concise procedures outlining step-by-step action, with appropriate caution and warning notes, provide an assurance of uniform safe operation of the plant by all operating personnel. The various operations performed on the plant, such as starting up the reactor, bringing the plant to power, or shutting down, should be outlined in detail. The initial conditions of the plant, the steps to perform the operation, and the final condition should be specified. Precautions and limitations must be expressed clearly for the complete understanding of everyone. Since the industry is in a development stage, and each plant may differ from others in important aspects, specific procedures must be written for each particular plant. Procedures from operating plants are very useful in formulating methods and practices which are applicable.

CONCLUSION

The Atomic Energy Commission has the responsibility for licensing, regulating, and inspecting the nuclear industry in this country. To participate in the uses of atomic energy, organizations must comply with prescribed regulations and requirements to protect the health and safety of the public. One of the requirements is that each licensee must have suitable training or experience to possess and use the material or facility safely for the purpose for which it is licensed. For a plant to fulfill this obligation, a comprehensive training program as outlined is requisite. Competent operating personnel will aid materially in the advancement and development of the atomic power industry.

The Television Allocations Study Organization

G. R. TOWN
FELLOW AIEE

Growing complexity of frequency spectrum allocation problems since World War II, caused mainly by rapid television growth, has brought about formation of an FCC-suggested television industry-wide organization (TASO) to study the engineering factors involved. The general objectives and progress of the Television Allocations Study Organization to date are discussed by its executive director.

THE ALLOCATION OF FREQUENCIES to the various classes of radio services has been a serious problem from the earliest days of the wireless art. Historically, it was the necessity for an orderly allocation plan for radio broadcasting which led to the formation in 1927 of the Federal Radio Commission. The Federal Communications Commission (FCC), which succeeded the Federal Radio Commission in 1934, is still faced with allocations problems and these problems increase in complexity with the ever-greater demand by the expanding electronics industry for space in the frequency spectrum.

The rapid growth of television broadcasting since World War II has resulted in especially critical problems, caused partially by the wide band of frequencies required for each television channel and, in part, by the desirability of providing television viewers with a choice of programs from several stations. The technical difficulties implicit in the situation led to the 1948-52 "freeze," during which time no grants were made for the construction of new television stations, and to the opening of the uhf band (Channels 14-83, or 470-890 mc) to commercial television broadcasting upon the lifting[1] of the "freeze."

Although a considerable number of uhf stations are in successful operation, uhf television broadcasting has not spread as rapidly as had been anticipated. Some of the reasons are technical and some commercial. This situation has greatly complicated the allocations problems before the FCC which is faced with a demand for more television channels and, at the same time, a reluctance on the part of prospective broadcasters to accept available uhf assignments. At the same time, other services which also need more space in the spectrum covet the channels assigned to television broadcasting in both the uhf and the vhf (channels 2-13) regions.

In its *Report No. 2875* of June 26, 1956, the FCC discussed various ramifications of the allocations problem and suggested the possibility of ultimately shifting all television broadcasting to the uhf region. It was pointed out, however, that before anything of this nature could be done (if indeed, it should become practicable), many technical problems would need to be solved and the FCC suggested that the television industry make a concentrated attack on these engineering problems.

On August 31, 1956, the FCC issued its *Public Notice 35638* in which it noted that the FCC had called a meeting of representatives of the television broadcasting and manufacturing industries to be held on September 20, 1956, for the purpose of establishing an organization to conduct an investigation into the engineering factors affecting the allocation of frequencies to television broadcasting. The organizations invited to the meeting were the Association of Maximum Service Telecasters, the Committee for Competitive Television, the Joint Council on Educational Television, the National Association of Radio and Television Broadcasters and the Radio-Electronics-Television Manufacturers Association (since renamed the Electronic Industries Association [EIC]). The scope of the investigation requested by the FCC was considerably broader than that visualized in its June 26 report, inasmuch as the studies were to include not only an inquiry into the uhf problems, but also a general consideration of "the technical principles which should be applied in television channel allocation."

The television industry responded to the FCC's request by establishing the Television Allocations Study Organization (TASO). The organizational meetings of this group were under the chairmanship of Dr. W. R. G. Baker, president of RETMA (EIC). In the three months following the initial meeting on September 20, a "Statement of Policies and Operations" (or charter) was drawn up and approved, a plan of organization was adopted and an executive director was employed. The planned activities of the organization commenced on January 1, 1957, when the executive director assumed office with headquarters in Washington, D. C.

OBJECTIVES OF TASO

THE OBJECTIVES of TASO are well expressed in the following quotation from the charter:

> "The objectives of the organization shall be to develop full, detailed and reliable technical infor-

Essentially full text of a conference paper presented at the AIEE Fall General Meeting, Chicago, Ill., Oct. 7-11, 1957. Recommended for publication by the Television and Aural Broadcasting Systems Committee.

G. R. Town is executive director, Television Allocations Study Organization, Washington, D. C.

mation, and engineering principles based thereon, concerning . . . uhf and vhf television service. The principles, plus full supporting technical data shall be made available by TASO to the Federal Communications Commission so that the Commission may be able to determine the soundest approach to television channel allocations. TASO's functions shall be limited solely to technical study, fact finding and investigation, and interpretation of technical data."

To carry out the objectives of TASO, the organization shown in Fig. 1 has been established. The policy making group is the board of directors which consists of two representatives of each of the five sponsoring organizations. The engineering studies are carried on by six panels of engineers and by appropriate committees and subcommittees of the panels. The work of the various panels is unified through actions of the Panel Co-ordinating Committee which consists of the chairmen and vice-chairmen of the panels and the executive director. The latter is responsible for the administration of the activities of TASO. Members of the staff of the FCC serve as observers on all panels and also preside at meetings of the board of directors and of the panels and committees in order to comply with the suggestions of the Department of Justice with respect to the operation of industry groups advisory to governmental agencies.

The administrative expenses of TASO are borne through financial contributions from the five sponsoring organizations. The much larger expense involved in the operation of the panels is borne directly by the companies by whom the panel members are employed.

PANEL TASKS

THE TASKS ASSIGNED to the six panels are indicated by their names and by the organization charts of Figs. 2, 3, and 4. Panels 1 and 2 on "Transmitting Equipment" and "Receiving Equipment" respectively are making detailed studies of the performance characteristics, not only of television transmitters and receivers, but also of the associated antennas and transmission lines and of repeater transmitters. Panel 4 on "Propagation Data" is making an exhaustive analysis of existing data on the strength of service fields and of interferring signal fields, and is also conducting extensive measurements of the propagation of signals from representative uhf and vhf television stations in various sections of the country. Panel 3—Field Tests—is concerned with the performance of television receiving equipment in the home and with the correlation of this performance, as judged by both engineers and lay observers, with field strength as measured by Panel 4. Panel 5 on "Analysis and Theory" has the task of fitting the information obtained by the other panels into a co-ordinated picture of the entire television system as indicated in the panel-prepared Fig. 1 of R. M. Bowie's article, which appears on page 129 of this issue, and of presenting this information in such a form as to be most useful for allocations purposes. Panel 6, which was established recently upon the recommendation of Panel 5 and the Panel Co-ordinating Committee, is concerned with specifying what constitutes a satisfactory television picture in the presence of various types of interfering signals and noise. The tasks of the panels will be discussed in detail in subsequent papers at this session.

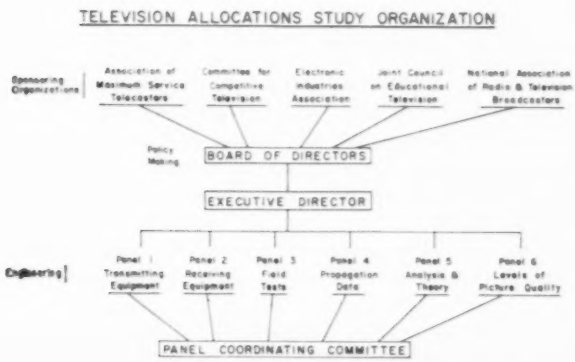

Fig. 1.

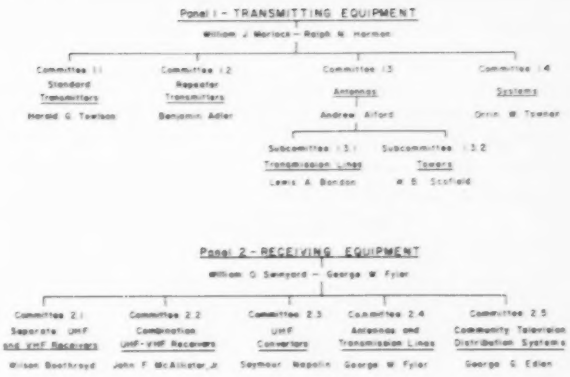
Panel 1 - TRANSMITTING EQUIPMENT
William J. Morlock — Ralph N. Harmon
Committee 1.1 Standard Transmitters — Harold G. Townson
Committee 1.2 Repeater Transmitters — Benjamin Adler
Committee 1.3 Antennas — Andrew Alford
Committee 1.4 Systems — Orrin W. Towner
Subcommittee 1.3.1 Transmission Lines — Lewis A. Bondon
Subcommittee 1.3.2 Towers — W. S. Stafield
Panel 2 - RECEIVING EQUIPMENT
William G. Swenyard — George W. Fyler
Committee 2.1 Separate UHF and VHF Receivers — Wilson Boothroyd
Committee 2.2 Combination UHF-VHF Receivers — John F. McAllister, Jr.
Committee 2.3 UHF Converters — Seymour Napolin
Committee 2.4 Antennas and Transmission Lines — George W. Fyler
Committee 2.5 Community Television Distribution Systems — George G. Eden

Fig. 2.

The success of any venture such as TASO depends primarily upon the engineers who serve on the technical panels. TASO has been particularly fortunate in securing outstanding engineers as officers and members of its panels, committees and subcommittees. These have been drawn from all branches of the television industry in all parts of the country. A total of 168 engineers from 88 organizations are serving as panel members, alternates, and observers and still others are serving on committees. These men work for manufacturers of television transmitters and receivers, for broadcasting networks, for independent high and low power uhf and vhf television stations, for engineering consulting organizations, for educational institutions, for technical publishing houses and for governmental agencies. It is believed that the TASO membership represents an unusually able and inclusive cross section of the entire television engineering profession.

Organization of the TASO panels commenced in

January 1957, and the first meeting of the Panel Co-ordinating Committee was held on February 4, 1957. Since that time, there have been 38 meetings of the panels and of the Panel Co-ordinating Committee, plus many committee meetings. Questionnaires have been prepared and circulated to manufacturers, broadcasters, and television servicemen to gather needed data and arrangements have been made to facilitate the rapid analysis of these data. Wave propagation measurements have been made in the Norfolk, Va.; Wilkes-Barre and Scranton, Pa.; and New Orleans and Baton Rouge, La., areas; and field performance surveys have been conducted in New Orleans and Fresno, Calif. Field work of both types has been planned for other areas of the country. A significant step forward has been taken in the establishment of standard methods for taking field strength data at both uhf and vhf. Studies are being made of the operation of uhf boosters and translators in New England and of unusual vhf wave propagation effects in Virginia. A tremendous amount of data on tropospheric propagation collected by the Central Radio Propagation Laboratory of the National Bureau of Standards over a period of several years is being studied and analyzed.

SCOPE OF FUTURE WORK

LOOKING TOWARD THE FUTURE, a vast amount of work remains to be done. Wave propagation measurements still must be made in many areas and the Panel 3 field tests are actually just getting under way. The work of Panel 6 has only commenced recently. In addition to these broad areas of study, a considerable number of investigations of a more restricted scope need to be made within the purview of the various panels. These include studies of such diverse topics as the determination of the true power radiated in a given direction from an installed transmitting antenna; the possible effectiveness of cross polarization and of circular polarization; the determination of the optimum ratio of radiated sound-to-picture power; the effectiveness of various types of receiving antennas; the deterioration of receiving antennas and transmission lines with age; the relationship between receiving antenna height and the developed signal voltage; the description and specification of characteristics of the terrain which affect wave propagation; the description and specification of the ambient conditions at the receiving antenna site which affect the received signal; the relative values of noise and of multipath effects, or ghosts at uhf and vhf; the relative reception of color television at uhf and vhf; the extent to which repeater transmitters are useful or are required under various conditions; the methods by which the effects of interfering signals from two or more sources should be combined; and the method for the best presentation of data on television station coverage. Finally, there will be the essential task of preparing the final reports in which all pertinent information is summarized and conclusions are drawn.

In summary, it can be said that significant progress has been made to date, that there is a large amount of activity on many engineering fronts and that a great deal remains to be accomplished. There appears to be a well-founded expectation that as a result of these activities, TASO will make a significant contribution to the television allocations problem.

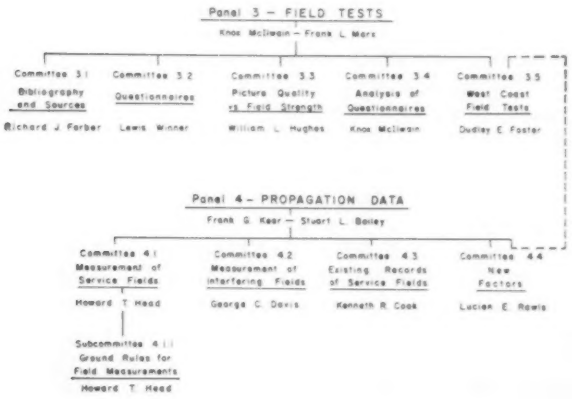
Panel 3 – FIELD TESTS
Knox McIlwain – Frank L. Marx
Committee 3.1 Bibliography and Sources
Richard J. Farber
Committee 3.2 Questionnaires
Lewis Winner
Committee 3.3 Picture Quality vs Field Strength
William L. Hughes
Committee 3.4 Analysis of Questionnaires
Knox McIlwain
Committee 3.5 West Coast Field Tests
Dudley E. Foster
Panel 4 – PROPAGATION DATA
Frank G. Kear – Stuart L. Bailey
Committee 4.1 Measurement of Service Fields
Howard T. Head
Subcommittee 4.1.1 Ground Rules for Field Measurements
Howard T. Head
Committee 4.2 Measurement of Interfering Fields
George C. Davis
Committee 4.3 Existing Records of Service Fields
Kenneth R. Cook
Committee 4.4 New Factors
Lucien E. Rawls

Fig. 3.

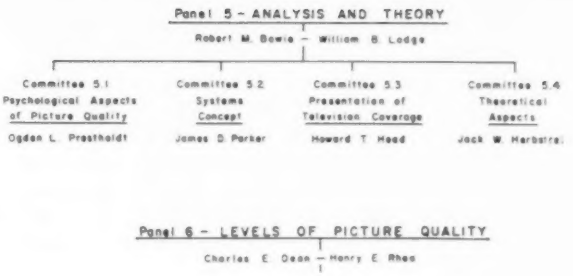
Panel 5 – ANALYSIS AND THEORY
Robert M. Bowie – William B. Lodge
Committee 5.1 Psychological Aspects of Picture Quality
Ogden L. Prestholdt
Committee 5.2 Systems Concept
James D. Parker
Committee 5.3 Presentation of Television Coverage
Howard T. Head
Committee 5.4 Theoretical Aspects
Jack W. Herbstreit
Panel 6 – LEVELS OF PICTURE QUALITY
Charles E. Dean – Henry E. Rhea

Fig. 4.

REFERENCES

1. "Television Allocation Trends", O. W. B. Reed, Jr. *Electrical Engineering*, vol. 76, June 1957, pp 484-89.

Missile Headache Cure

Bromo-seltzer can be used to cure missile headaches, too, General Electric missile engineers disclosed.

To house recording instruments during test flights of these missiles, GE engineers developed a spherical capsule which is carried in the missile nose cone and is ejected before the nose cone hits the earth. Electrically operated markers help engineers locate the sphere. However, to function properly, these markers must be delayed for a few minutes before operation. Bromo-seltzer, packed around electrical wires, delays completion of the electronic circuit for the few minutes required for operation.

Systems Approach to Determination of Television Coverage

R. M. BOWIE

Taso's systems concept integates information obtained by its panels into a form that can be most useful to the FCC for allocation purposes. The essential elements of the system are discussed and the contributions of some of the panels to this system are presented.

IN ORDER to take into proper consideration all of the effects that bear upon the picture transmission process, the systems concept has been adopted by Television Allocations Study Organization (TASO).

The Ad Hoc Committee[1,2] in its reports of 1949 and 1950 implicitly employed the systems concept. The problems of forecasting and depicting coverage of potential stations particularly are dealt with there in considerable detail. Other features of the systems concept are included directly or inferentially.

The transmission of a television program from the studio to the viewer's screen is a multipart system in which the performance capabilities of each part bear upon the performance of other parts and upon the excellence of the end product—the program at the receiver. It is necessary, therefore, to interrelate the capabilities and characteristics of the various parts in order to arrive at an optimum specification of the whole. To better visualize what is meant by the systems concept, reference is made to Fig. 1. This is known as the Systems Concept Chart and was developed by Panel 5. The essential parts include the transmitter and its antenna, the propagation path or paths to the receiving antenna, the receiving antenna itself, and finally the receiver. Interfering elements must be included also, such as competing television transmitters with their propagation paths, multipath transmission of the wanted signal and other extraneous disturbances such as cosmic and ignition noise.

For simplicity, Fig. 1 shows the essential elements of the system, but it does not include the extraneous elements such as adjacent-channel stations. Starting at the right are the transmitter and its antenna. These are within the province of Panel 1 on Transmitting Equipment. Although the system properly includes, in addition, all of the steps from the studio to the transmitter, it is the opinion of TASO that the generation of the video signal is not part of the allocation problem because this signal is adequately specified and controlled by Federal Communications Commission (FCC) regulation. We shall assume, therefore, that a video signal of standard technical quality is available.

The propagation path extends to the receiver antenna and is the province of Panel 4 on Propagation Data. The work of this panel will, of necessity, overlap considerably with that of Panel 1 on Transmitting Equipment and Panel 2 on Receiving Equipment, as propagation is so intimately related to the properties of the transmitting and receiving antennas. Panel 4 is concerned with unwanted propagations, also, which will be mentioned later.

The receiving antenna, its location and its lead line vary widely from one installation to another. How to cope with these variations in characterizing a minimum serviceable installation is one of the tasks of Panel 2. In like manner, receivers vary markedly and for this reason Panel 2 will deal with the characterization of their minimum serviceable performance also. It is expected that, finally, the receiver and its antenna will have to be considered together in arriving at the overall characteristics of a minimum serviceable receiver plant.

The final judge of the performance of the system is the observer. Unfortunately observers are not constant, uniform, calibrated instruments but have a wide statistical variation in response. The assignment of Panel 6 on Levels of Picture Quality is to develop statistical relationships between objective picture quality and human satisfaction.

Panel 6 did not exist originally. It was brought into being at the request of TASO's Panel Co-ordinating

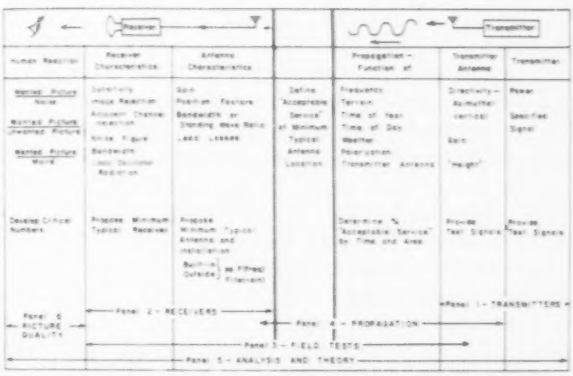

Fig. 1. Systems Concept Chart.

Essentially full text of a conference paper presented at the AIEE Fall General Meeting, Chicago, Ill., Oct. 7-11, 1957. Recommended for publication by the Television and Aural Broadcasting Systems Committee.

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Committee after it was determined by Committee 5.1 on psychological aspects of picture quality of Panel 5 that sufficiently complete and consistent data on this field of human reaction do not now exist. There are two other panels of TASO not shown on the diagram. One is Panel 3 on Field Tests, which is concerned with the over-all observational evaluation of the system in the field. The other is Panel 5 on Analysis and Theory which also has an over-all responsibility including that of bringing together the technical findings of the other panels in a consistent and authoritative technical report for the use of the FCC.

In following through the systems concept, it seems best to start with the observer and work backward along the path of the signal to the space immediately surrounding the receiving antenna. In this manner, it is possible to determine the wanted signal strengths required and the levels of unwanted signals that can be tolerated. Starting then with the transmitting antenna expressions are derived, which may have to be statistical and partially empirical, for the field strength to be expected at that receiver location.

We have thus progressed from both ends of the system by logical steps to the space where the receiving antenna is to be located. If the field strength at the antenna site can statistically be expected to exceed that required for just-acceptable service, then the receiver location is within the service area of the transmitter.

The receiver site (Fig. 2), which is located at some distance from the transmitter, has an assumed acceptable reception 90% of the time. Thus, if an area of several square miles around this receiver is examined, in general, it will be found that some receiver sites receive acceptable signals less than 90% of the time and others more. Let us assume further that 50% of receiver sites, chosen at random, receive acceptable signals at least 90% of the time. This area then falls outside of the Grade A service range as defined by the FCC because the definition of that grade of service requires that at least 70% of sites in the area receive acceptable signals at least 90% of the time. Actually, this area is at the limit of the Grade B service range. If now the entire region about the transmitter were divided into areas similar to the one described and the probability of service were to be determined for each, quite a clear picture of the service area of the transmitter would be gotten.

A major objective of TASO is to develop means for predicting, before a station is erected, what service it will render and what interference to other stations it may introduce. The fineness of detail with which this can be done will depend largely upon the technical findings of Panel 4 from its extensive field tests assisted by the theoretical examination of the data by Committee 5.4 on theoretical aspects.

The description given of field strength prediction is intended to introduce the closely related problem of portraying television station coverage. This problem is the responsibility of Committee 5.3 on presentation of television coverage, which is now in the midst of its deliberations. It is considering at least three ways of depicting service area, as shown somewhat schematically in Fig. 3. The first is that of dividing the region surrounding a transmitter into areas and showing on a map the expected level of service for each area. In order to avoid being too explicit about the meaning of "level of service," as Committee 5.3 has not yet spoken on this matter, suffice it to say that in the expression (50,90), for example, the 90 represents the percentage of the time that acceptable signals are received at a particular receiver site and the 50 represents the percentage of randomly chosen receiver sites in the area experiencing acceptable reception at least 90% of the time. The areas are shown laid out in a regular manner, although this is not necessary. The second method is to draw isoservice contours through the centers of areas having essentially the same levels of service. These contour lines would probably be as irregular in shape as elevation contours about a hill. The third method involves drawing profiles of the level of service along specified radii. I have shown curves for four radii only. There would need to be many more. It is the intent of Committee 5.3 to develop from these approaches a revised method of portraying television coverage in a form that will provide improved usefulness to the FCC for allocation purposes.

Let us now return to the Systems Concept Chart (Fig. 1) and examine in greater detail the kind of information that will be required about each component part of the system. As before, we shall start with the observer and work toward the space immediately about the receiving antenna, then start at the transmitter and work toward that same space.

THE OBSERVER

To obtain a statistically significant relation between abstract picture quality and subjective satisfaction, it will be necessary first to consider what populations of observers should be studied. For example, are rural residents who are remote from a transmitter to be considered as being different from urban residents? In short, are there to be two or more grades of television service? The answer is a matter for the FCC to decide. It may be necessary, however, to seek FCC guidance while Panel 6 is making its psychological reaction studies, as the selection of populations for study may need to be correlated with the grades of service.

When the populations to be sampled have been chosen, the next step will be to obtain viewer reactions to measured levels of different kinds of picture signal degradation. The means for producing the pictures with these measured levels of the forms of signal degradation to be studied have not yet been worked out, as Panel 6 is so new as to have had only one meeting. One method proposed, for monochrome pictures at least, is that of making kinescope recordings of a monitor onto which a form of degradation will be introduced in progressively increasing degree. The resulting recordings will then be shown to observer groups using television-set-like viewing conditions. The observers will then score

the parts of the recording as to level of acceptability using such terms as excellent, good, satisfactory, just usable, and unacceptable. Employing established methods of psychological reaction testing, these scorings will be reduced to curves relating picture acceptability to level of degradation for each population tested. From these curves, it will be possible to select the tolerable levels of degradation. These curves are expected to be of value to the FCC in its task of setting acceptance limits for the grades of service which it establishes.

Particular attention will have to be given to the effect of two or more types of signal degradation simultaneously. This problem was raised by Panel 4, and has been referred both to Panel 6 and to Committee 5.4 on theoretical aspects for study. Color also introduces problems both in the preparation of test films or, alternatively, of pictures on an actual color tube as well as in finding suitably conditioned observers. There is also the problem of determining the form of the picture signal degradation that results from various forms of interference such as cochannel reception. The appearance of the degradation will depend upon the properties of the receiver circuitry and, in some degree, upon the antenna. To a lesser extent this is true also of monochrome reception. Panel 6 will be guided by Panel 2 in determining the appearance of the various forms of degraded signals.

THE RECEIVER

THE RECEIVER essentially is a device that transforms the received signal into a visible picture with accompanying sound. It has rejection capabilities against certain forms of unwanted or degraded signal, such as adjacent-channel interference or image interference, and it has internal faults of its own which limit its performance, such as equivalent input noise level and bandwidth limitations. Some of these characteristics bear directly upon the ability of the receiver to display the wanted signal; others bear upon its ability to discriminate against unwanted signals. Based on these various receiver characteristics, it should be possible to state both the level of desired signal required and the levels of unwanted signals that can be tolerated if the receiver is to produce a picture having just acceptable quality as determined from the observer tests mentioned earlier. Thus, the observer norms of just-acceptable picture quality are translatable into minimum input signal level and maximum ratios of undesired signals to the desired signal. For example, the just-acceptable desired signal in microvolts should be stated, while the maximum tolerable interfering signal from an adjacent-channel station should be given as so many db with respect to the wanted signal.

The selection and sorting out of the pertinent receiver characteristics is the task of Panel 2, as is also the gathering of data on these characteristics for sets currently on the market or in the field. It is important to know not only the characteristics of sets of various makes when new, but also the extent to which the original characteristics are degraded after a reasonable length of time in service.

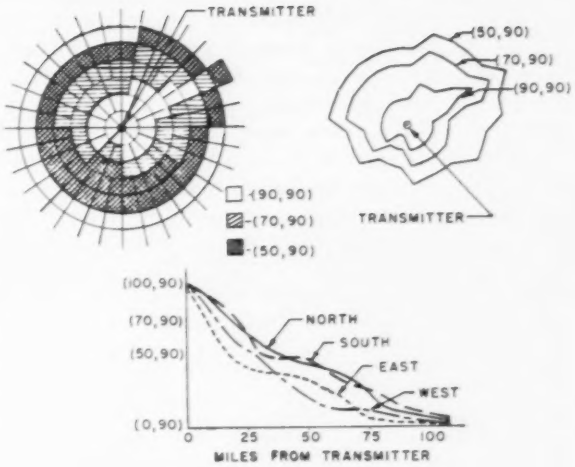

Fig. 3. Three ways of depicting service area.

Inasmuch as the present study is to guide future station assignments, estimates of these characteristics are desired for receivers that will be in the hands of the public five years hence. The required data probably will have to be obtained by the FCC directly from industry. The selection of the characteristics of the minimum serviceable receiver expected to be in the field five years hence is a matter of industrial technical judgment, not of public policy. Therefore, it would seem proper for Panel 2, rather than the FCC, to make this selection using data provided by the FCC from its survey of the industry.

Using the characteristics to be derived for the minimum serviceable receiver, the observer norms of just-acceptable picture quality can then be translated into the limits of just-acceptable receiver input signal.

THE RECEIVING ANTENNA AND LINE

IN THE SAME MANNER as with the receiver, it will be necessary to determine the characteristics of the minimum serviceable antenna, antenna installation, and line. Such factors as antenna directivity patterns and line losses enter the problem. Of particular interest is the effect of the directivity pattern on the rejection of unwanted signals.

When the characteristics of the minimum serviceable antenna and installation have been selected by Panel 2, it will then become possible to translate the observer norms of just-acceptable picture quality into the minimum-acceptable field strength required at the receiver antenna location.

The computation of the characteristics of the minimum serviceable receiving plant by multiplying the

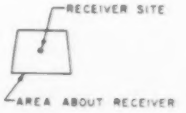

Fig. 2. Receiver site located some distance from transmitter.

characteristics of the minimum serviceable receiver by the appropriate characteristics of the minimum serviceable antenna, seems straightforward. Actually, one must take into consideration the fact that statistically this receiver and this antenna are not likely to be together in the same receiving plant. Hence statistical means must be used in arriving at the characteristics of the minimum serviceable receiver plant. One may expect that there will have to be a minimum serviceable receiver plant postulated for each grade of service established.

We have now progressed backward along the path of the television signal from the observer to the space surrounding the receiving antenna. Starting with the statistical reaction of observers, we have now developed the means for specifying the minimum wanted field strength and the field-strength ratios for maximum permissible signal degradations at the limit of a service area. It is now appropriate to start again at the transmitter and to work forward to that same receiver antenna location.

THE TRANSMITTER

THE VIDEO SIGNAL to the transmitter, as was pointed out, may be assumed to meet the FCC standards and, therefore, consideration of its origin and transmission need not be included in a discussion of the systems concept. The operation of the transmitter itself may also be assumed to comply with FCC regulations, consequently we shall pass by these two points.

Having stated the transmitter power and the maximum permissible degradations of the input signal, it is now possible to consider the next link in the chain, the transmitting antenna. The task of characterizing the part played by that antenna overlaps the propagation studies. Matters such as antenna gain, pattern, and effective height are all tied intimately with propagation. It would be desirable, for example, to know just how far one can go in narrowing the vertical pattern of an antenna before undesirable effects occur both within and beyond the horizon. Thus, the provinces of Panels 1 and 4 are in part overlapping.

Another problem is the suitability of the two-to-ten mile rule used in specifying transmitter antenna heights. The height is taken with reference to the average terrain height between two and ten miles from the transmitter, and this rule has provided a rough approximation for computing coverage. Its accuracy in the vhf has been questioned, while its application in the uhf is doubtful. A theoretical study of this problem has been requested and the task has been assigned to Committee 5.4 on theoretical aspects.

PROPAGATION

THE PROPAGATION LINK in the chain presents many uncertainties in predicting the signal levels to be expected in the service area of a transmitter. The problem is made difficult by many vagaries of propagation and the uncontrollable variables. Further, many of the phenomena involved are not yet understood. The signal at any point appears to be a function not only of controllable variables, such as antenna configuration and location and transmitter power, but also of the time of the day and season of the year. The topographical features of the intervening terrain including buildings, wooded areas, and hills are influencing factors as we all know. Even more unpredictable is the effect of unwanted signals that may be propagated by anomalous ionospheric or atmospheric conditions. Although predictability of signal at any one receiver site may be unacceptably poor, it does appear that service and interference can, in general, be predicted with useful accuracy by employing statistical methods.

It is my opinion that the performance of TASO in its task of providing means for predicting the coverage of a potential television station will be bounded by the ability of Panel 4 to predict propagation. The other steps in the technical tasks of TASO appear reasonably amenable to solution by the exercise of established scientific and engineering methods.

THE OVER-ALL SYSTEM

THUS FAR, the successive links or parts which make up the communication path from the transmitter to the observer have been described briefly, together with the extraneous effects which interfere. However, a description of the components of a system cannot fully define its over-all performance. It is essential, therefore, to test the composite of the links by adequate over-all field measurements. Obviously, the resulting data will have to be studied statistically. The development of the method of statistical analysis to be employed has been assigned to Committee 5.4 on theoretical aspects at the request of Dr. G. R. Town, executive director of TASO. The field testing and the statistical analysis of the data are jobs assigned to Panel 3, although that panel has other tasks also.

The proving out of the systems concept by means of over-all field tests involves the careful design of experiments. This may prove to be somewhat of a task because receivers in the field will not usually be of minimum serviceable quality, but will probably be both worse and better. Furthermore, the leveling action of the automatic gain control (agc) in the receiver will tend to obscure the variations in field strength from location to location which one desires to determine.

The final task of Panel 5 will be to prepare the report of the technical findings of TASO. This report, after review and approval, is to be submitted to the FCC. It is desired that this document provide technical guidance to the FCC in making television station assignments of the future. It will, of course, be fully supported by the reports and records of each of the separate panels.

REFERENCES

1. Ad Hoc Committee for the Evaluation of the Radio Propagation Factors Concerning the Television and Frequency Modulation Service in the Frequency Range between 50 and 250 mc, FCC Report No. 36830, vol. I, May 31, 1949.

2. *Ibid.*, FCC Report No. 54382, vol. II, July 7, 1950.

Gas Flow and Heat Transfer in Conductor-Cooled Units

L. T. ROSENBERG

FELLOW AIEE

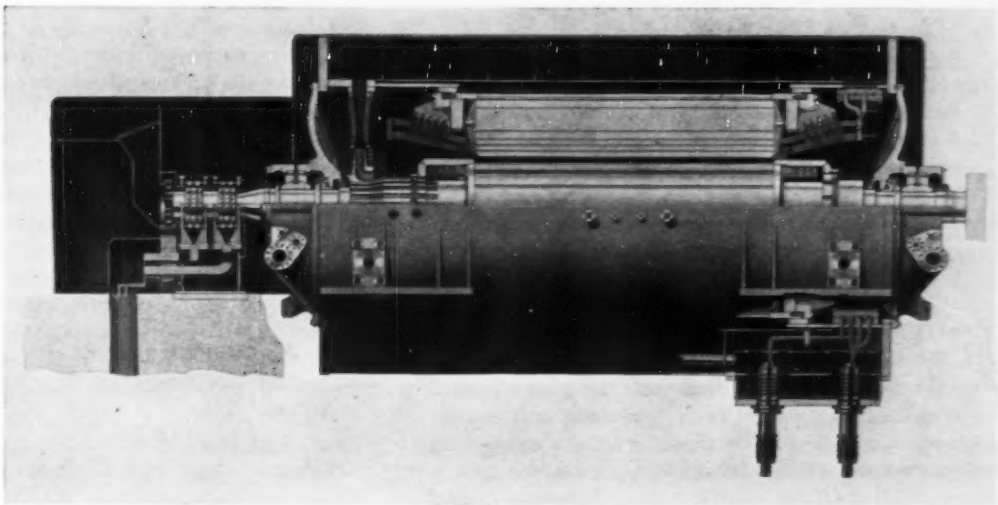

Fig. 1. Interior arrangement of conductor - cooled generator.

SINCE THE INSTALLATION of the first 60-mw turbine–generator with a supercharged rotor in 1951, a substantial number of large conductor-cooled machines have been placed in operation, and many more are under construction. However, very little has been published of the details of calculation peculiar to this type of cooling.

Fig. 1 shows a typical cross section of a large fully supercharged generator having a single centrifugal blower on the outboard end for ventilating the entire machine. Gas flow is from end to end in the stator core, coils, and air gap, but from both ends toward center in the rotor windings.

For accurate temperature prediction, the losses and their distribution must be known. Gas flow in the ducts is also important and may be determined with the help of curves giving the Reynolds number and duct friction factors obtained from tests on the particular type of ducts being considered.

The heat transfer coefficients are also readily determined with the help of curves based on the relation for turbulent flow:

$$\frac{hD}{k} = 0.023\, N_{Re}^{0.8}\, N_{Pr}^{0.4}$$

where

h = Surface heat transfer coefficient

D = Equivalent duct diameter

N_{Re} = Reynolds number = $\dfrac{\text{Velocity} \times D \times \text{Density}}{\text{Viscosity}}$ (1)

k = Thermal conductivity of the gas

N_{Pr} = Prandtl number = $\dfrac{\text{Viscosity} \times \text{Specific Heat}}{k}$

Gas rise curves in terms of kw absorbed per cubic foot per minute of gas, based on the specific heat of the gas, are plotted for convenient reference as a function of gas pressure.

Temperature drops within the copper and iron are usually small in conductor-cooled machines but can be accounted for with the help of derived expressions for the various patterns of flow. The steady-state internal distribution of stator core temperature surrounding an axial duct, for example, can be shown to be

$$t = \frac{q'''}{2k_r}\left[r_2^2 \ln \frac{r}{r_1} - \frac{r^2 - r_1^2}{2} \right] \qquad (2)$$

expressed in degrees Centigrade above the duct wall temperature, where

q''' = The core loss in watts per cubic inch

k_r = Thermal conductivity of core in radial direction, watts per square inch per degree C per inch

r_2 = Outside radius in inches of cylindrical core region to be cooled

r = Radius in inches at the location where the temperature rise is desired

r_1 = Radius in inches of the cooling duct

Flow of heat through insulation and other parts having no internal loss is calculated using thermal resistance of x/kA for solids and $1/hA$ for surfaces, where

x = Length of path in inches

A = Cross section of path, square inches

k = Conductivity, watts per square inch per degree C per inch

h = Surface heat transfer, watts per square inch per degree C

Digest of paper 57-1006, "Gas Flow and Heat Transfer in Conductor-Cooled Machines," recommended by the AIEE Rotating Machinery Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Fall General Meeting, Chicago, Ill., Oct. 7-11, 1957.

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Dimensions for a Unified Theory of Electromechanics

L. W. ALLEN

A relation is derived from classical electromagnetics which dimensionally relates a mechanical quantity, force, to an electrical quantity, voltage. A set of three dimensions—length, time, and the square root of force—result, which are sufficient to present dimensionally a unified theory of electromechanics. The extension of dimensional theory and unified theory is also discussed.

FOR MANY YEARS, it has been found necessary in dimensional analysis to use a minimum of four dimensions in order to dimension the quantities and to form the equations of both mechanics and electromagnetic theory. For mechanics alone, three dimensions suffice; two sets of dimensions in common use in mechanics consist of the quantities force F, length L, and time T, or alternately mass M, L, and T. (The word "quantity" will be used throughout to mean any one of the characteristics of mechanical, electromagnetic, or heat theory, such as mass, voltage, force, time, temperature, etc.; and when a particular quantity is being used as a dimension, the convention of placing brackets [ ] about its symbol will be followed.) The need for a fourth dimension in a combined theory of electromagnetics and mechanics (which will be called hereinafter "electromechanical" theory) has arisen because it has been considered necessary to have a fundamental electric quantity that is dimensionally independent from mechanical quantities. The most common electrical quantity that has been used as a dimension, independent from the mechanical dimensions, is charge Q. A complete set of electromechanical dimensions has consisted of a minimum of four dimensions, such as $[F,L,T,Q]$, or alternately $[M,L,T,Q]$. These sets are typical of many that can be formed. A comparison of these, and of other dimensional sets, will be found in Eshbach.[1] The basic philosophy of dimensional analysis is stated in the works of Buckingham.[2-4] A more complete discussion is given by Bridgman,[5] and by several modern authors, such as Langhaar.[6]

While four dimensions have been considered necessary, it can be shown that three dimensions are sufficient to form a complete set of electromechanical dimensions. The three dimensions are the square root of force $[\sqrt{F}]$, $[L]$, and $[T]$. In the application of this set, the dimensions of the electrical quantities are expressed in terms of $[\sqrt{F},L,T]$; while the dimensions of the mechanical quantities are expressed in terms of $[\sqrt{F^2},L,T]$. Force is replaced by the square root of force as a fundamental dimension.

In order to apply the set $[\sqrt{F},L,T]$ to electromechanical quantities, it is necessary to link the new dimension, $\sqrt{F}$, with both mechanical and electromagnetic quantities. The new dimension is obviously linked with the mechanical quantities:

$$[\sqrt{F^2}] = [F] \tag{1}$$

It will be demonstrated that the new dimension is also related to the electrical quantities by the relation of $\sqrt{F}$ to voltage V:

$$[\sqrt{F}] = [V] \tag{2}$$

or in words, the dimension of voltage is the square root of force. This relation, to the author's knowledge, has not been set forth in the literature; but it can be derived from an equation of classical electromagnetic theory, using established principles of dimensional analysis. The equation referred to is to be found in Abraham and Becker[7]:

$$F = QE + \frac{1}{2} r^3 \frac{k-1}{k+1} \operatorname{grad} E^2 \tag{3}$$

The three terms of equation 3 will be identified separately hereinafter, from left to right, as term 1, term 2, and term 3. Equation 3 relates the vector force F (term 1) on a charged dielectric sphere of dielectric constant k and radius r to two independent component forces which are caused by the action of an external electric field of E volts per unit length intensity on the sphere. One of the independent component forces (term 2) is due to the interaction of the charge on the sphere with the external field; the other component force (term 3) is due to the interaction of the dielectric and the external field gradient. The sphere and the external field are assumed to be placed in a vacuum.

The derivation of equation 2 is started by adopting as axiomatic the principle of dimensional homogeneity, as stated by Buckingham[2]: "The principle of dimensional homogeneity states that all terms of any correct and complete physical equation must have the same dimensions." By application of this principle, the dimensions of each term of equation 3 can be equated to the dimensions of the other terms. One of the three resultant dimensional equations, relating term 1 to term 3, is used for the derivation:

A special article recommended by the AIEE Basic Sciences Committee.

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$$[F] = \left[\left(\frac{1}{2}\right)(r^3)\left(\frac{k-1}{k+2}\right)(\text{grad})\,(E^2)\right] \qquad (4)$$

The five factors of term 3, as shown on the right-hand side of equation 4, can be reduced as follows:

1. The fraction has unity dimension and can, therefore, be eliminated from further consideration.

2. The second factor, r^3, has the dimensions L^3.

3. The third factor, $(k-1)/(k+2)$, can be eliminated by applying the principle of dimensional homogeneity. The numerator contains two terms, which must be of the same dimensions; the denominator contains the same kind of terms and, therefore, has the identical dimensions that the numerator has; the numerator and denominator cancel, leaving unity dimension for the third factor, which can be eliminated from further consideration.

4. The dimensions of grad are $1/L$; this can be multiplied by the result of step 2, giving L^2 as a product.

5. The dimensions of E^2 are V^2/L^2; this factor can be combined with the result of step 4, giving V^2 as a product.

6. The reduced dimensions of term 3 are, therefore, V^2. Substituting this result into equation 4 gives

$$[V^2] = [F] \qquad (5)$$

which reduces to equation 2.

By forming a second dimensional equation from terms 1 and 2, the dimensions of Q are determined to be $\sqrt{F}L$.

By successive substitution of the relation of equation 2 in the equations of electromagnetic theory, the dimensions of all known quantities of electromagnetism can be defined in terms of the dimensional set $[\sqrt{F},L,T]$. Table I shows the dimensions of the common electromagnetic quantities. Some of these quantities, such as R, $\mathcal{L}$, and C have only length–time dimensions, and will be put in a separate category below. For the convenience of the reader who wishes to follow the substitutions, the two right-hand columns show the equations used by the author, and the page number in Skilling[4] where they can be found. Note the dimensions of E, D, μ, and Hf.

Table II shows the dimensions of common mechanical quantities, expressed in terms of the dimensional set $[\sqrt{F},L,T]$.

If equation 3 is a correct and complete physical equation, if the dimension of E is correctly stated as $[V/L]$, and if the principle of dimensional homogeneity is accepted as axiomatic, then the definition of equation 2 is rigorous, and the new set of dimensions has a valid theoretical basis. It has been assumed that equation 3 is a correct and complete physical equation. This assumption is based on the logical derivation of equation 3 by Abraham and Becker.[2] This assumption is given further weight by the simple, physically demonstrable situation represented by equation 3—the forces on a charged dielectric sphere immersed in an ambient electric field. In line with modern thought, the dimensions of E are assumed to be $[V/L]$, with no dimensional distinction between voltage, potential, and emf. Historically, a distinction has sometimes been drawn between static potential, potential drop, and emf; if future developments should justify a return to this or a similar viewpoint, then the derivation of equation 2 should be reviewed at that time. The dimensional set $[\sqrt{F},L,T]$ is as valid as equation 2.

Another check on the validity of the new dimensional set can be made by substituting the new dimensions in an equation which can be derived independently from the equations of classical electromagnetism. An equation of this sort is one which relates the velocity of light c to k and μ:

$$c = \frac{1}{\sqrt{k\mu}} \qquad (6)$$

Upon substitution, the resultant dimensions of each term are seen to be equal. The validity of the dimensional set is enhanced by this demonstration.

Table I. Dimensions of Electrical and Associated Length–Time Quantities in Terms of $\sqrt{F}$,L,T

Symbol	Dimension	Name	Equation No.	Page No.*
V	$\sqrt{F}$	Voltage	3	—
E	$\frac{\sqrt{F}}{L}$	Electric field intensity	3	—
Q	$\sqrt{F}L$	Charge	3	—
B	$\frac{\sqrt{F}T}{L^2}$	Magnetic flux density		81
k	1	Absolute dielectric constant		4
ρ	$\frac{\sqrt{F}}{L^3}$	Charge per unit volume		52
D	$\frac{\sqrt{F}}{L}$	Electric flux density		53
H	$\frac{\sqrt{F}}{T}$	Magnetic intensity		111
I	$\frac{\sqrt{F}L}{T}$	Current		70
μ	$\frac{T^2}{L^2}$	Magnetic permeability		85
R	$\frac{T}{L}$	Resistance		74
$\mathcal{L}$	$\frac{T^2}{L}$	Inductance		103
C	L	Capacitance		59
ϕ	$\sqrt{F}T$	Magnetic flux		79
A	$\frac{\sqrt{F}L}{T}$	Magnetic vector potential		92
U^*	$\frac{\sqrt{F^2}}{LT}$	Poynting vector		133
$\mathcal{E}^*$	$\sqrt{F^2}L$	Energy		65
p^*	$\frac{\sqrt{F^2}L}{T}$	Power		—
$\frac{Q}{M}$	$\frac{L^2}{\sqrt{F}T^2}$	Charge to mass ratio		—

* Mechanical, rather than electrical, quantities.

The foregoing demonstrates, from a theoretical viewpoint, that a fundamental electrical quantity, independent of mechanical quantities, is not a necessary condition for the validity of electromagnetic theory. For example, equation 2 relates mechanical theory to electromagnetic theory by equating the dimensions of a mechanical quantity, force, to the dimensions of an electrical quantity, voltage. The theoretical mutual dependence of electrical and mechanical quantities can also be demonstrated from a physical viewpoint. Instances can be cited where the interaction of electrical phenomena gives rise to mechanical phenomena: for example, the interaction of electromagnetic fields caused by electric currents passing through parallel wires produces mechanical forces; the interaction of two charged dielectrics in proximity also produces forces. In view of known phenomena such as these, it does not appear possible to justify an opposite viewpoint, namely that a fundamental electric quantity, independent of mechanical quantities, is necessary for the validity of electromagnetic theory. This is not to say that the dimension $\sqrt{F}$ is a mechanical dimension: it is not, because it does not appear to the first power in any equation of mechanics. Neither is it to be inferred that $\sqrt{F}$ is necessarily identical with voltage; although this appears possible, it is not certain, inasmuch as some known nonidentical quantities (e.g., torque and energy) appear to have identical dimensions. It appears best at this time to leave a determination of the nature of $\sqrt{F}$ open to future developments.

Table II. Dimensions of Mechanical and Associated Length-Time Quantities in Terms of $\sqrt{F}$,L,T

Symbol	Dimension	Name
F	$\sqrt{F^2}$	Force
$\mathcal{B}$	$\frac{\sqrt{F^2}T}{L}$	Viscous friction
S	$\frac{\sqrt{F^2}}{L}$	Elastance, surface tension
p	$\frac{\sqrt{F^2}}{L^2}$	Pressure, tension, stress
d	$\frac{\sqrt{F^2}T^2}{L^4}$	Density
Im	$\sqrt{F^2}T$	Impulse, momentum
M	$\frac{\sqrt{F^2}T^2}{L}$	Mass
h	$\sqrt{F^2}LT$	Planck's constant, action, angular impulse, angular momentum
$\mathcal{E}$	$\sqrt{F^2}L$	Energy, torque, Boltzmann constant
T	T	Time
θ	1	Angle
$\dot{\theta}$	$\frac{1}{T}$	Angular velocity, frequency
$\ddot{\theta}$	$\frac{1}{T^2}$	Angular acceleration
L	L	Length
u	$\frac{L}{T}$	Velocity
α	$\frac{L}{T^2}$	Acceleration
Hf	$\frac{L^2}{T^2}$	Heat of formation, vaporization, solution
Ar	L^2	Area
Vol	L^3	Volume

Maxwell[9] derived the relation $Q=\sqrt{F}L$ in a different manner first by assuming k to be a pure number, i.e., to have unity dimensions, and then by using the relation of force to two charges separated by an arbitrary distance. He apparently did not extend this result to include the relation of equation 2, or to dimension in a like manner the rest of the electrical quantities. While the derivation given here eliminates the need for Maxwell's assumption, nevertheless, the agreement between Maxwell's result and the dimensions for Q given here constitutes additional argument for the validity of equation 2.

The use of $[\sqrt{F}]$ in place of $[F]$ as a dimension overcomes a logical objection to dimensional systems such as the Gaussian (wherein dimensions appear to various fractional powers of M, L, T), voiced by Williams and quoted in Bridgman[3] (page 46): "So long, however, as L, M, and T are fundamental units, we cannot expect fractional powers to occur . . . Now all dynamical conceptions are built up ultimately on terms of these three ideas, mass, length, and time, and since the process is synthetical, building up the complex from the simple, it becomes expressed in conformity with the principles of Algebra by integral powers of L, M, and T . . . Obviously if mass, length, and time are to be ultimate physical conceptions, we cannot give interpretations to fractional powers of L, M, and T, because we cannot analyze the corresponding ideas into anything simpler. We should thus be unable, according to any physical theory, to give interpretation to formulae involving fractional powers of the fundamental units." Williams' logical objection is overcome in the new dimensional set by stating that the fractional power of force $\sqrt{F}$ is the fundamental quantity, rather than force F.

Thus, the novel relationship expressed in equation 2 links a mechanical quantity F to an electrical quantity V and, thereby, makes possible a unified theory of electromechanics. A set of three dimensions $[\sqrt{F},L,T]$ is shown to be sufficient to dimension the combination of all mechanical and electrical quantities and is, therefore, suitable for dimensioning a unified theory.

Possible approaches to the development of unified theories, and the application of the new dimensional set to problems of dimensional analysis and dimensional synthesis are considered in the following sections.

APPLICATION AND EXTENSION

The DIMENSIONAL SET $[\sqrt{F},L,T]$ can be applied to dimensional analysis and to dimensional synthesis. The set can also be used as a starting point for the extension of theory.

Dimensional Analysis. The new dimensional set is useful in dimensional analysis of electromechanics, in-

asmuch as it simplifies the dimensional equations by reducing the number of necessary dimensions from four to three. The set is also useful because the reduction from four to three dimensions allows the quantities of electromechanics to be related in a system of three-dimensional co-ordinates, in which relations that are difficult or impossible to see in a four-dimensional system can be seen.

The three-dimensional co-ordinate system is shown in Fig. 1(A). The origin of the co-ordinates is unity dimension. One axis is the "length" axis; one is the "time" axis; and the third is the "square root of force" axis. The scale on each axis is logarithmic: for example, the "length" axis proceeds in the positive direction from the origin in equal steps L, L^2, L^3, and in the negative direction in equal steps L^{-1}, L^{-2}, L^{-3}. The origin is $L^0=1$, $T^0=1$, $\sqrt{F}^0=1$, as is required by this type of scale.

The space about the co-ordinate system can be sliced into various interesting planes. Three of these, shown in Fig. 1(B), are of immediate interest: the length–time section, which is a plane perpendicular to the $\sqrt{F}$ axis, through the origin; the electrical section, a plane perpendicular to the $\sqrt{F}$ axis, and intersecting it at a distance of $\sqrt{F}$; and the mechanical section, perpendicular to the $\sqrt{F}$ axis and intersecting it at a distance $\sqrt{F}^2$. All electrical and mechanical quantities can be placed on these three sections. Quantities from Tables I and II are plotted by their dimensions on the three appropriate sections, as shown on Figs. 2(A), 2(B), and 2(C). Alignment of the three sections is indicated by the squares with the included circles; these are the places where the $\sqrt{F}$ axis penetrates through the sections. Corresponding electrical, mechanical, and length–time quantities, differing in dimensions only by a power of $\sqrt{F}$, are determined by this alignment. Among quantities which correspond are force, the square root of force, and unity dimension; energy (and torque), charge, and length; power, current, and velocity. Several vertical groups have corresponding positions: for example, L, u, and a descend by powers of time; C, $1/R$, and $1/\mathcal{L}$ have corresponding positions on the same section, while $1/C$, R, and $\mathcal{L}$ have inverse positions. The positions of $\mathcal{L}$, R, and $1/C$ on the length–time section also correspond to the positions of M, $\mathcal{B}$, and S on the mechanical section.

An example will be given of the use to which these dimensional relations can be put. The vertical groups mentioned previously are related to the well-known analogous equations of electromechanics:

$$V = \mathcal{L}\frac{dI}{dT} + RI + \frac{1}{C}\int I\,dT \tag{7}$$

$$I = C\frac{dV}{dT} + \frac{1}{R}V + \frac{1}{\mathcal{L}}\int V\,dT \tag{8}$$

$$F = M\frac{du}{dT} + \mathcal{B}u + S\int u\,dT \tag{9}$$

$$u = \frac{1}{S}\frac{dF}{dT} + \frac{1}{\mathcal{B}}F + \frac{1}{M}\int F\,dT \tag{10}$$

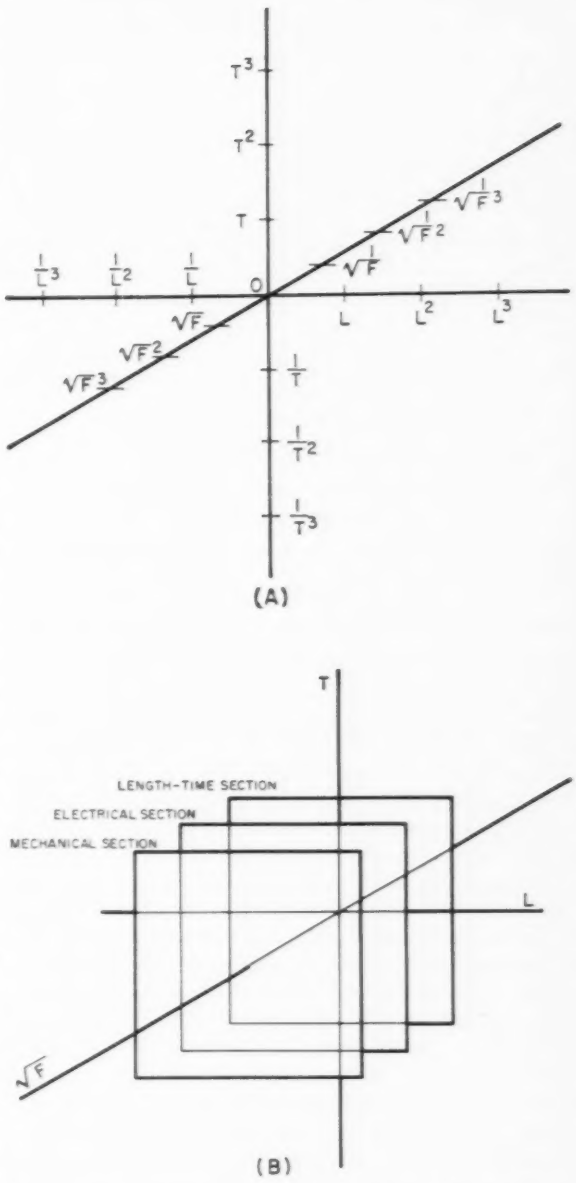

Fig. 1. (A) Dimensional co-ordinates; (B) sections of the dimensional space.

The analogous relationships among equations 7 to 10 are explained in some detail in Gardner and Barnes.[10] All four equations are analogous, since they have identical mathematical forms. The mathematical form common to all of these equations can be expressed as

(1st Variable) = (1st Constant) (Derivative of 2nd Variable)
+ (2nd Constant) (2nd Variable)
+ (3rd Constant) (Integral of 2nd Variable) **(11)**

The question often has been raised as to the difference in relationships among the analogous equations. Some of the differences can be indicated by plotting the dimensional positions of the factors of equation 11 on the

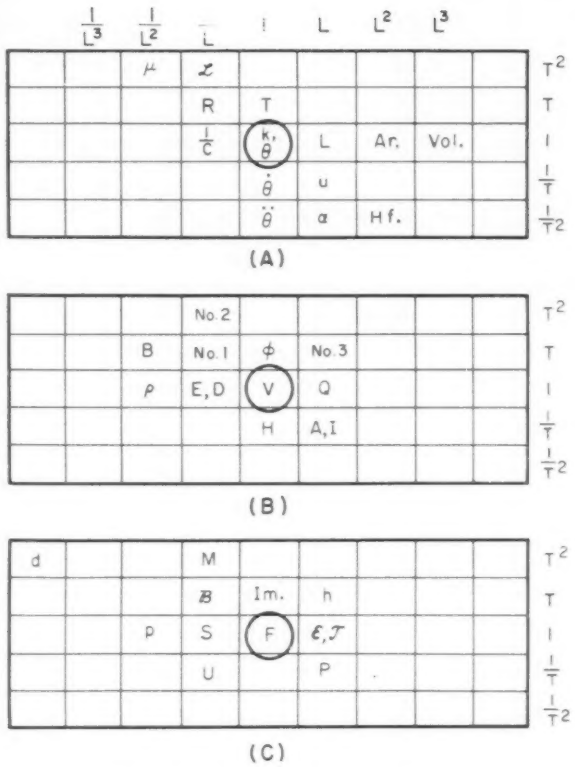

Fig. 2. Quantities plotted by their dimensions on the three appropriate sections: (A) length–time section, (B) electrical section, and (C) mechanical section.

co-ordinate system of Fig. 2, for each of equations 7 to 10. For example, equation 7, when divided into the factors of equation 11, assumes the form

$$(V) = (\mathcal{L})\left(\frac{dI}{dT}\right) + (R)(I) + \left(\frac{1}{C}\right)\left(\int I\,dT\right) \qquad (7a)$$

By reference to Table I or Fig. 2, the dimensional factors of equation 7 are located; these are plotted in Fig. 3(A). Lines drawn between adjacent positions give a geometrical form. The same procedures are followed with the analogous equations, and the results are plotted in Figs. 3(B) to 3(D). Examination of Fig. 3 shows that the form of the electrical equation 7 is most closely related to the form of mechanical equation 9, but that their dimensional relations have an inverse symmetry about the $\sqrt{F}$–T plane. The form of electrical equation 8 is more closely related to the form of mechanical equation 10 than is true with equations 7 and 9, since their forms, shown in Figs. 3(C) and 3(D), do not exhibit the inverse symmetry that is exhibited in the forms of equations 7 and 9, Figs. 3(A) and 3(B). Accordingly, it might be expected that equations 8 and 10, when used together, will be of wider application than will equations 7 and 9. This expectation is born out in practice.

In addition to dimensional analysis of the sort illustrated in the preceding example, the sections of the dimensional co-ordinate system can be used as a shorthand method of checking dimensions. For example, one of Maxwell's equations is

$$\text{curl } E = -\frac{\partial B}{\partial T} \qquad (12)$$

The dimensions of this equation can be visually checked by locating B on the electrical section, Fig. 2(B). The operator $\partial / \partial T$ moves the dimensional position of the right-hand term from the position of B to the next position vertically below B; the operator curl moves the position of the left-hand term from the position of E one place horizontally to the left of E; the positions of the two terms coincide, so the dimensions of Maxwell's equation, as written in equation 12, are correct. Similarly, the dimensional correctness of all the equations of electromechanics can be checked quickly.

This example concludes, but does not exhaust, the applications of the new set to dimensional analysis. While applications such as these are important, applications of greater immediate significance are taken up later, and include the use of the dimensional set as a means of synthesizing equations, of extending the bounds of electromechanical and dimensional theory, of predicting the existence of unknown phenomena, and of forming unified theories. The applications given in the foregoing are applications of dimensional analysis; the applications given below are applications of dimensional synthesis. The foregoing applications can be tested by the usual analytical and logical methods; most of the applications which will be discussed must be verified by experiment, prior to analysis.

Dimensional Synthesis. The simplest type of synthesis is the synthesis of known equations from operations on the dimensional co-ordinate sections (Fig. 2). All of the equations of mechanical and electromagnetic theory can be derived by the use of the sections of Fig. 2, provided that one term of the equation is known. Inasmuch as this operation is essentially the inverse of the operation illustrated in the first example of the preceding section, no example will be given. Several rules and precautions must be observed when operating on the dimensional sections during synthesis:

1. The dimensions of any quantity may be inverted; and, since the inversions are symmetrical about the origin, the inverted quantity will be found in a position on a line from the upright position through the origin, and equidistant on the opposite side of the origin. Inversion of this type is illustrated in Fig. 3(D).

2. For movement between the electrical, mechanical, and length–time sections, the dimensions at the starting position must be combined with a power of $\sqrt{F}$, either negative or positive, depending on the direction of progression.

3. A precaution is necessary with regard to the structure or situation the relations of which are described by the equation under consideration: all quantities and terms chosen on the dimensional space for any particu-

lar equation must be a part of the same structure or situation. For example, the defining equation for electric current in terms of charge is

$$\frac{dQ}{dT} = I \tag{13}$$

If equation 13 is synthesized, starting from the position of Q on the electrical section, Fig. 2(B), the operator d/dT moves the dimension of the left-hand term one position vertically downward. In this position are to be found both A, the magnetic vector potential, and I, the current. Since equation 13 applies to a particular situation or structure involving Q and I, and presumably not involving A as well, one must choose I rather than A for inclusion in equation 13.

4. A precaution with regard to operators which occur in the equation is also necessary. For example, the operators—curl, divergence, and gradient—all have the same dimension $[1/L]$ and all move the position of the term one position to the left: yet all three operators have different structural interpretations. The difference lies, from a structural standpoint, in the difference in orientation of each operation. Changes in orientation and location are not indicated in the dimensional system of this article, although further refinement in dimensional theory appears possible which will eliminate ambiguities due to location and orientation. Further discussion of orientation and location will be given in a following section.

Extension of Electromagnetic Theory. The new dimensional system, when put in the form of Fig. 2, can be used as a starting point for discovery that may lead to the extension of electromagnetic theory. For example, on the electrical section, Fig. 2(B), magnetic flux ϕ, V, and magnetic intensity H are seen to be spaced vertically one position apart. There are several groups of three quantities spaced in the same manner, which result in important and useful relations, as previously mentioned. Since ϕ and H can exist in the same structure, and since ϕ is related to V by Faraday's equation

$$\frac{d\phi}{dT} = V \tag{14}$$

Another plausible relation is

$$\frac{dV}{dT} = H \tag{15}$$

This relation, to the author's knowledge, has not been specifically stated in the literature. The argument given does not, and is not intended to, constitute proof that such a relation exists; it does show how the dimensional sections can be used as a starting point for an investigation. Of equal value to a proof that the relation of equation 15 is valid is proof that it is invalid. In other words, if the relation of equation 15 is invalid, why is it invalid?

Another investigation can be launched by considering the three dimensional sections (Fig. 2) to be aligned in proper position along the $\sqrt{F}$ axis. The reader can imagine that he is standing back along the $\sqrt{F}$ axis, with the mechanical section in front of him, the electrical section directly behind the mechanical section, and the length–time section behind the electrical section. The sections are aligned by the point where the $\sqrt{F}$ axis penetrates them. The reader will note that M, $\mathcal{B}$, and S on the mechanical section are aligned with L, R, and $1/C$ on the length–time section, as previously noted. All of these quantities are prominent in equations 7 to 10. However, in the corresponding positions on the electrical section, there are two blank positions, which are labeled no. 1 and no. 2; and in the third position on the electrical section are two quantities, E and D. Because of the importance of these three positions on the mechanical and length–time sections, and because of their interrelations, it appears plausible that the two blank positions, no. 1 and no. 2, are also important positions, and may partially define two unknown electrical quantities. No. 1 has the dimensions $[\sqrt{F}T/L]$; no. 2 has the dimensions $[\sqrt{F}T^2/L]$. The dimensions are necessary but are not sufficient to define the nature of the unknown quantities. Other relations between the unknown and known quantities must be discovered before the unknowns can be completely defined. Similarly, Planck's constant h is aligned with blank position labeled no. 3 on the electrical section, which leads to the possibility that no. 3 might also be an important electrical quantity. Potentially important quantities, such as nos. 1 to 3, might be useful in the theoretical treatment of electrical phenomena which have been handled with difficulty by present theory. Experimentation will be required to determine the existence or nonexistence of unique relations between known and unknown quantities. A principle of general application

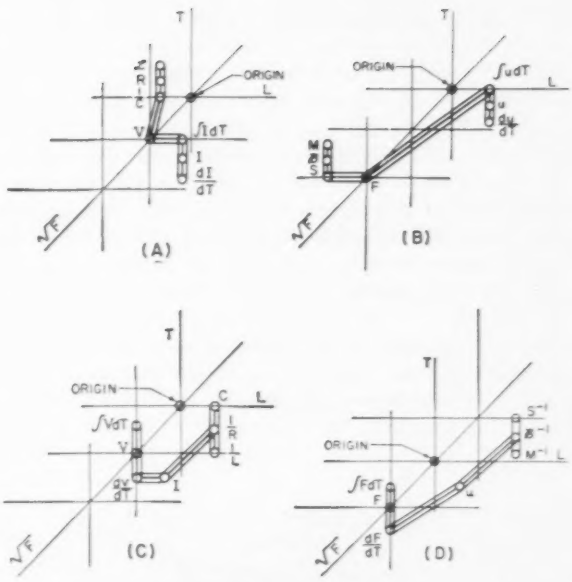

Fig. 3. Dimensional factors of (A) equation 7, (B) equation 9, (C) equation 8, and (D) equation 10.

is illustrated by the example just given: any blank spot in an otherwise ordered informational array is a good spot from which to launch an investigation.

Extension of Dimensional Theory. Dimensional theory, which has been extended in the foregoing by the reduction of the number of dimensions required for electromechanics from four to three, and by the use of a dimensional co-ordinate system, appears to be capable of further extension by the inclusion of structural considerations, such as location and orientation. Orientation is a fundamental structural relation, which relates the direction of one part of a structure to another. Location is likewise a fundamental structural relation, which relates the position of one part of a structure to another. Conditions of location are implied in all equations. For example,

$$V = R\,I \tag{16}$$

is valid only when V, R, and I are all located in the same circuit; the equation obviously is invalid when V and R are located in independent circuits. Orientation is also implied in all equations. The plus and minus signs of the equations indicate polarity, which is a kind of orientation. Orientation and location are closely related to dimensions. A clue to a possible relation between orientation and the dimensional set $\sqrt{F},L,T$ is to be found in the vectorial treatment of the square root of a negative number, in which the direction of the imaginary is changed in orientation from the direction of the real vector.

Extension of Unified Theory. The synthesis of a unified theory of electromechanics, as well as an approach to the synthesis of a unified theory of general application, is made possible by further consideration of dimensions. A unified theory is one which is formed by combining two or more parts, each of which, up to the time when combination becomes possible, contained terms and quantities that could not be combined with terms and quantities of the other parts to form unified equations. At the time when combination becomes possible, a relationship is discovered which allows the quantities of all parts to be merged into single equations. Inasmuch as the principle of dimensional homogeneity applies to the equations of unified theories, it follows logically that a unified theory must have a set of dimensions which is common to all parts of the theory. Further, because the lack of a common set of dimensions was the reason why the parts could not be combined originally, it also follows that the relationship, discovered at the time combination becomes possible, must necessarily be a dimensional relationship. Equation 2 is a dimensional relationship which will allow mechanical and electromagnetic theory to be combined into a unified theory of electromechanics. Other relationships, similar in form to equation 2, must be found in order to form more general unified theories, such as a thermoelectromechanical theory or a thermoelectromechanical-gravitational theory.

The number of dimensions in a unified theory will not exceed three. The utilization of a fourth dimension amounts to an admission that no specific relation exists between the phenomena described by the parts of the theory; and such an admission is contrary to the physical relations that are observed to exist between parts, for example, between electromagnetic and heat theory. Three dimensions are shown here to be sufficient to dimension a unified theory of electromechanics by changing a familiar dimension $[F]$ to an unfamiliar dimension $[\sqrt{F}]$. More general unified theories probably will result in further change in the set $[\sqrt{F},L,T]$.

It is possible that no further change in the dimensional set will be necessary. In this case, the dimensions of the thermal quantities must be $[\sqrt{F^n},L,T]$, where n might be 3, for example, resulting in a thermal section in front of the mechanical section of Fig. 2. This possibility appears unlikely.

It appears more probable that a change will be necessary in the set $[\sqrt{F},L,T]$; the change that seems most likely is achieved by taking the square root of either L or T, or both, resulting in a set such as $[\sqrt{F}, \sqrt{L}, \sqrt{T}]$. Both $\sqrt{L}$ and $\sqrt{T}$ occasionally appear in physical equations; if such equations are correct and complete, then there is logical justification for the use of the general set $[\sqrt{F}, \sqrt{L}, \sqrt{T}]$.

The formation of a unified electromechanical theory, using the set $[\sqrt{F},L,T]$, should result in further discovery of new electromechanical relations. The illustrations that have been given are largely electrical in nature. Further exploration of electromechanical relations is desirable. For example, a relation which needs to be clarified is that of mechanical friction to static electricity.

An essential step for the formation of further theory, as mentioned previously, is experimentation. A unified theory requires synthesis; and, just as a mathematical proof gives validity to an analysis, so experimental verification gives validity to a synthesis. Experimentation will be necessary to establish the validity and develop the usefulness of unified theories.

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Working Group Report on Mobile Substations

AIEE SUBSTATIONS COMMITTEE

MOBILE SUBSTATIONS have been used in various forms for more than 20 years. Initially, it was usually a standby or emergency device and particularly in conjunction with the increasing use of 3-phase transformers.

Today, many companies have one or more of these completely self-contained substations and they are being used by maintenance and construction forces to provide service during maintenance or rearrangement of permanent facilities in addition to being available for emergencies.

A survey has been made of 32 scattered companies representing 78 mobile units in 22 states and one Canadian province to review ratings, type, operation, methods of installation, means of phasing, purpose for which used, and the effect, if any, on system design policies. Of the units surveyed, 54% fell in the 2,000 to 3,000 kva range with highest primary voltage 115 kv and lowest secondary voltage 115 to 199.

The average installation time for a mobile substation is 6 to 8 hours based on over 3,400 locations where it can be used. Approximately 75% of the installations would not require services of a watchman. In cutting a mobile unit into service it is paralleled with existing equipment at some 3,177 locations and the load to be picked up is de-energized at 227 locations. The question of correct phasing shows a few companies do not phase at 526 locations while most companies do determine proper phasing at 3,351 locations.

Where a company has more than one unit, the importance of use varies with the number of units available. Generally, the degree of importance, or purpose for which mobile units are used, is in the following order:

(1) equipment failures; (2) scheduled maintenance; (3) short-term construction, 30 days or less; (4) long-term construction, over 30 days; and (5) temporary loads.

Approximately 50% of the companies owning mobile substations consider them as reserve capacity, and 67% of the companies report that mobile substations are resulting in less installed reserve capacity and less stock transformer capacity.

Replies indicated that the need for connections to mobile substations generally does not influence the design and layout of permanent substations. At 4,085 locations where "mobiles" are used, 46% are located in the permanent substation yard and 34% on adjacent property. At 3,315 locations, 48% can use the permanent fence and 50% erect a temporary fence for protection of the public. At 4,132 locations, 88% provide temporary grounding facilities by connection to present ground grid and 11% use temporarily driven rods.

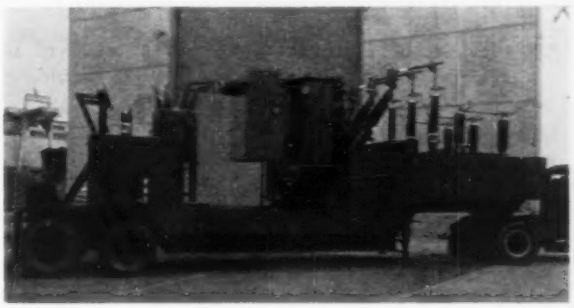

Fig. 2. Typical recent mobile substation, rated 9,000 kva, 66,000 to 2,520/4,360Y x 7,560/13,090Y volts.

A few companies have programs in which all existing substations have been and new substations are reviewed in advance of the need for using a mobile substation to determine position and method of connection. However, in both scheduled and emergency use, leaving the method of positioning and connecting to the field forces has generally been successful.

Experience has shown that a mobile substation has a high service reliability, improves service continuity, and has proved to be a good investment. Some companies have up to six units and the use of mobile substations is on the increase.

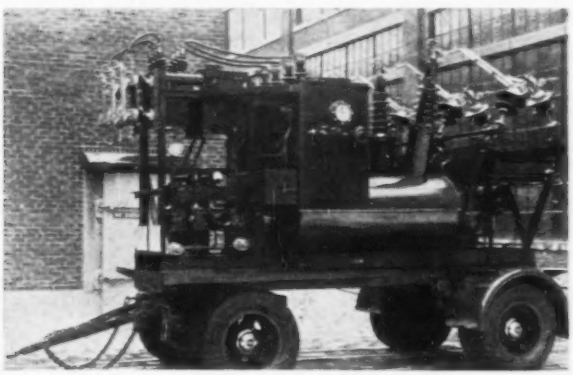

Fig. 1. Early mobile substation factory assembled in 1940, rated 2,000 kva, 36,000 to 2,300 x 4,600 volts.

Digest of paper 58-7, "Working Group Report on Mobile Substations—Their Use, and the Design of Distribution Substations To Facilitate Their Use," recommended by the AIEE Substations Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1958.

The members of the AIEE Substations Committee Working Group, Project 53.2 are: J. R. Dickey, G. F. Gleason, J. G. Hart, H. H. Marsh, Jr., J. A. Smith, P. R. Spracher.

Lightning Performance of 138-Kv Twin Circuit Transmission Lines

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Lightning flashover trip-out rate for 138-kv double circuit towers designed for one ground wire is far in excess of rate anticipated by Commonwealth Edison Company when installed in 1954. Results of studies are presented on the cause of these trip-outs. Significant differences in performance associated with change in design are pointed up.

THE 138-KV TRANSMISSION SYSTEM of the Commonwealth Edison Company is located in northern Illinois, as shown in Fig. 1. Based on United States Weather Bureau data, the isokeraunic level in this territory is between 40 and 45.

Prior to 1954, the majority of the Commonwealth Edison Company 138-kv double circuit towers were designed for two ground wires. Generally when one circuit was installed, the only ground wire installed was the one over the circuit. In 1954, 138-kv double circuit towers were placed in service designed for and using only one ground wire.

Based on calculations and experience involving both single and double circuits installed on double circuit towers designed for two ground wires, it was expected that the trip-out rate due to lightning flashover for the double circuit towers designed for one ground wire would be approximately two per 100 miles per year. Experience to date, however, shows on the average a trip-out rate far in excess of that anticipated. As a consequence, studies were undertaken to determine the cause of these heretofore unexplainable trip-outs.

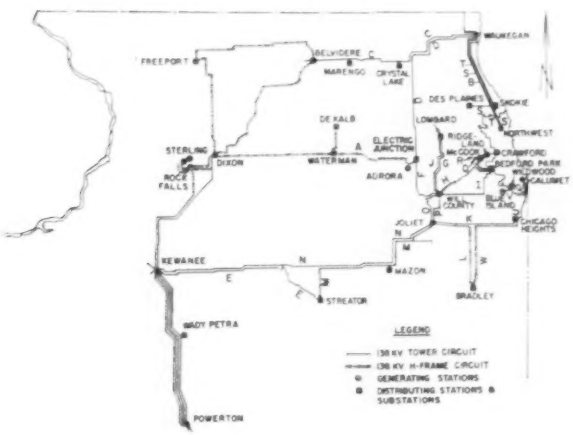

Fig. 1. 138-kv transmission system of Commonwealth Edison Company.

LIGHTNING PERFORMANCE

Two Ground Wire 138-Kv Tower. The outline dimensions of a typical double circuit tower with provisions for two overhead ground wires are shown in Fig. 2. This represents the configuration of the majority of the towers on which detailed performance data have been kept since 1927. The major portion of the towers in the Commonwealth Edison Company system have a footing resistance of 10 ohms or less with only a very few towers having a footing resistance over 40 ohms.

Over the period of time from 1927 to the present, the lightning performance of these towers has been very satisfactory under both conditions of one ground wire installed with one circuit and two ground wires installed with two circuits. Detailed records of trip-outs due to lightning flashovers have been kept continuously since 1927 on a portion of Commonwealth Edison Company system. These records show that the trip-out rate for circuits on towers designed for two ground wires but with only one installed is 2.11 per 100 year miles based on 3,781.75 year-miles and rate for circuits on towers designed for two ground wires with both installed is 1.24 per 100 year miles based on 6,351.43 year-miles.

Towers Designed for One Overhead Ground Wire. While the design covered by Fig. 2 has given satisfactory performance with respect to trip-outs due to lighting, it has not been satisfactory with respect to flashovers due to galloping of wires under ice and wind conditions. In order to improve the performance under galloping conditions, the configuration shown in Fig. 3 was developed and first circuits were put in service in 1954.

The expected trip-out rate due to lightning flashovers based on AIEE Committee Report[1] was about two per 100 miles per year. The performance of this new design with respect to trip-outs due to lightning has not been satisfactory.

Single Ground Wire Type of Tower. The following is a summary of the trip-out rate per 100 year-miles for circuits on single ground wire type of towers. In 1954,

Essentially full text of paper 57-1084, "Lightning Performance of 138-Kv Twin Circuit Transmission Lines of Commonwealth Edison Company Operating Experience and Field Studies," recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Fall General Meeting, Chicago, Ill., Oct. 7-11, 1957. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1957.

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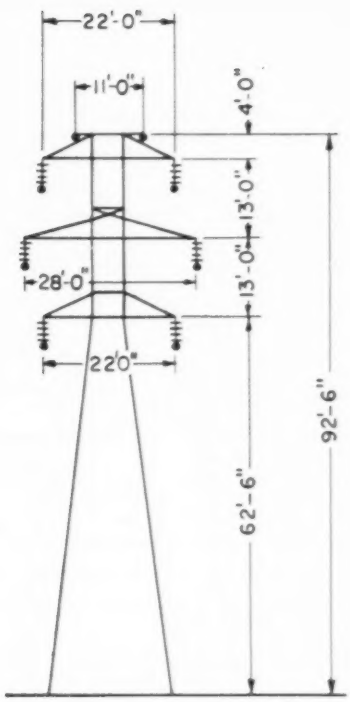

Fig. 2. Typical 138-kv double circuit tower with provisions for two overhead ground wires.

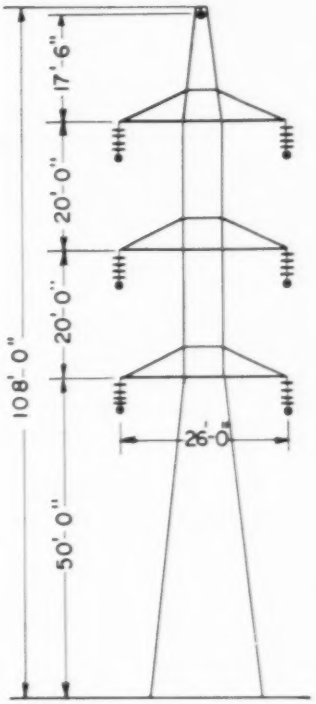

Fig. 3. New 138-kv double circuit tower with provisions for only one ground wire.

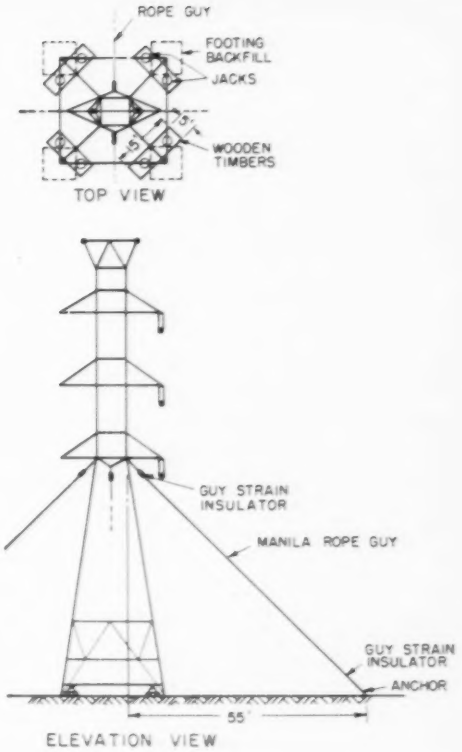

Fig. 4. Test tower, over-all view.

the rate was 80.5 for 13.66 circuit miles; in 1955, it was 10.12 for 69.14 circuit miles; and, in 1956, it was 2.17 for 91.93 circuit miles, giving a three-year over-all average of 11.44 trip-outs per 100 year-miles for 174.73 year-miles. The 1954 and 1955 rates are far in excess of expected value. The low 1956 rate may be caused, to a large extent, by less than the normal amount of lightning in 1956.

All of the flashovers involved the top phase and, in 1954, there were four instances where both 138-kv circuits flashed over on the same tower at the same time. Each flashover involved the top phase insulator string and was not a phase-to-phase flashover. A double circuit flashover on the same tower at the same time has rarely occurred on the two ground wire 138-kv type of tower.

The data show that where flashovers occurred on these single ground wire type of towers, the footing resistance was six ohms or less, and that about 70% of the flashovers have occurred on towers with a footing resistance of two ohms or less.

In most instances, the tower on which the flashover occurred was not any higher or as high as adjacent towers.

COMPARING TWO AND ONE GROUND WIRE TYPES

TABLE 1 gives a comparison of the lightning performance over the past three years of circuits on two ground wire types of towers, with one ground wire and with two ground wires installed and also on a single ground wire type of towers. In 1954, there were almost as many trip-outs on the 13.66 miles of single ground wire type of towers as on the 727.2 miles of two ground wire type of towers, with both ground wires installed. In 1955, there were 69.14 circuit miles on single ground wire type of towers, and the number of trip-outs was slightly higher than those experienced on the 147.93 circuit miles on double ground wire type of towers with one ground wire installed, and also more than on the 755.78 circuit miles on the towers with both ground wires installed. In 1956, the trip-out rate for circuits on towers designed for two ground wires but with only one installed was 2.02 as compared with 2.17 for circuits on towers designed for only one ground wire. However, as indicated in the foregoing, 1956 was a year with fewer lightning storms than normal for the Commonwealth Edison Company territory. For comparative purposes there is also included in Table 1 the cumulative performance data for the circuits on which data have been kept since 1927 for the period of 1927 to 1953, inclusive, and for the years of 1954, 1955 and 1956.

PHYSICAL CHARACTERISTICS OF TWO TYPES

THE PHYSICAL DATA for two ground wire type of tower and one ground wire type are given in Figs. 2 and 3. The tower arm spacing was increased from 13 feet to

Table I. Trip-outs of 138-Kv Circuits Due to Lightning Flashover

Comparison of Performance of Different Types of Towers

Year	Group of Lines Covered	Tower designed for 2 ground wires. See Fig. 2 for tower outline.						Tower designed for 1 ground wire. See Fig. 3 for tower outline.		
		1 Ground Wire Installed			Both Ground Wires Installed					
		Circuit Miles	Trip-outs	Trip outs per 100 Year Miles	Circuit Miles	Trip-outs	Trip outs per 100 Year Miles	Circuit Miles	Trip-outs	Trip outs per 100 Year Miles
1927 to 1953 incl.	Special — See Note 1.	3442.48 year miles	67	1.94	5501.41 year miles	65	1.18	—	—	—
1954	Special — See Note 1.	113.09	6	5.3	283.34	5	1.76	—	—	—
	C.E. Co. System	147.69	7	4.73	727.20	12	1.65	13.66	11	80.52
1955	Special — See Note 1.	113.09	5	4.42	283.34	4	1.41	—	—	—
	C.E. Co. System	147.93	5	3.31	755.78	6	.79	69.14	7	10.12
1956	Special — See Note 1.	113.09	2	1.76	283.34	5	1.76	—	—	—
	C.E. Co. System	147.93	3	2.02	757.12	11	1.45	91.93	2	2.17
1927 to 1956 incl.	Special — See Note 1.	3781.75 year miles	80	2.11	6351.43 year miles	79	1.24	—	—	—
1954, 1955 and 1956	C.E. Co. System	443.55 year miles	15	3.38	2240.10 year miles	29	1.29	174.73	20	11.44

Note 1: These are circuits or sections of circuits on which this type of data has been kept continuously since January 1, 1927.

20 feet to provide clearance for galloping conductors. In order to provide a 30° shielding angle it was necessary to increase the vertical ground wire-to-top conductor arm distance. The height of the basic single ground wire type of tower provides for a 650 foot span on level ground, but with the use of extensions the span may be increased to 750 feet, which is the maximum permitted by the arm separation in order to provide the minimum desired clearances between the two conductors under galloping conditions. The two ground wire type of tower had a ruling span of 880 feet, but tower extensions permitted appreciably longer spans. It is probable that the average single ground wire type of tower is about 20 feet higher than the average two ground wire type of tower. In each type the normal suspension insulator string consists of nine 5¾ inch × 10 inch units.

The single ground wire type of towers are used in areas where the terrain is the same as that where the two ground wire type of towers are used. The circuits on the towers designed for only one ground wire have not been exposed to any more lightning than the circuits on the towers designed for two ground wires.

INVESTIGATION OF SINGLE GROUND WIRE TYPE

SPECIAL EFFORTS were made to locate all of the flashovers that occurred on the single ground wire type of towers in an attempt to find a clue to the reason for the poor performance. In an area where several flashovers had occurred, the ground wire was lowered and inspected for burns due to lightning. A number of burns were found on the ground wire. In the same area, the top phase conductor was inspected and no burns were found on it. This leads to the belief that the ground wire is adequately shielding the phase wires and flashovers are not due to shielding failure.

Whenever a flashover was located, the insulator string involved was removed and replaced. These insulators were carefully inspected with particular attention being paid to marks made by lightning. In several instances, there was evidence of the stroke current on the entire upper and lower surfaces of each insulator in the string, indicating cascading. There were instances where it was not possible to detect surge markings on the entire surface of every insulator. Insulators that have been involved in flashovers on the two ground wire type of tower have been carefully inspected in the past. These also have, in some instances, showed surge markings on the entire surface of all units in a string and, in other cases, it was impossible to detect surge markings on the entire surface of every insulator.

TOWER MODIFICATIONS

AS A RESULT of the unsatisfactory operating experience in 1954 with the one ground wire type of tower, it was decided to modify towers being fabricated for erection in early 1955 to provide for two ground wires. This revision provided for two ground wires at the top of the tower at the same elevation above the top conductor arm as used in single ground wire type and with 15 feet horizontal separation between the two ground wires. Both ground wires were installed with the initial circuit. To date, there have not been any flashovers on these towers, but there have been only a few year-miles of service with them.

THE PROBLEM AND THE FACTORS INVOLVED

THE FOREGOING discussed the nature of the problem to be solved in terms of the disagreement between the performance predicted by calculation and that obtained from operating experience. One approach to the solution of the problem is to review critically the present methods of calculation and to determine whether or not some parameters or factors in the calculating procedures have been realistically evaluated. In this manner the AIEE method[1] perhaps needs only to be modified to extend its validity and usefulness.

Broadly, the AIEE method[1] of calculation from a circuit viewpoint is based on three areas of consideration:

1. Insulation strength of suspension insulator string.
2. Characteristics of lightning surges to transmission lines—magnitude, rate-of-rise, and duration of surge current.
3. Surge response of the transmission line to lightning strokes—footing resistance, tower impedance, coupling factor, effect of ground wires, etc.

The question of the impulse flashover characteristics of suspension insulators was the subject of recent laboratory investigations. Results of these studies are presented in other papers.[2-4]

With regard to item No. 2, there is some speculation pertaining to the magnitude and waveshapes occurring on transmission lines. Field investigations have been made in the past on transmission lines and on relatively tall structures, such as buildings and radio towers. There are some questions as to the direct applicability of these data to the transmission line problem. A field program was undertaken by the Commonwealth Edison Company and the American Gas and Electric Company to obtain more complete knowledge of the characteristics of lightning surges on the single ground wire type of towers. More data, through a continued recording of lightning strokes to these towers in the years to come, will be required to give a full evaluation of item No. 2. However, a portion of the results of these investigations are presented in another paper.[5]

Although laboratory investigations may substantiate the insulation strength characteristics of insulator strings and regardless of whether the results of the field investigations in regard to the characteristics of lightning surges agree or disagree with previously recorded data, it is possible to investigate item No. 3, the surge response of the tower and transmission line, for a whole range of possible variables and make hypotheses of what are occurring.

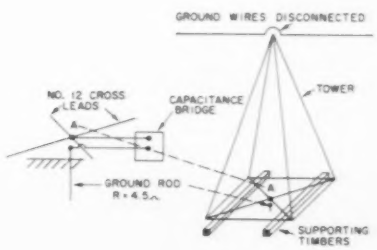

Fig. 5. Schematic diagram of test setup for base-of-tower measurements.

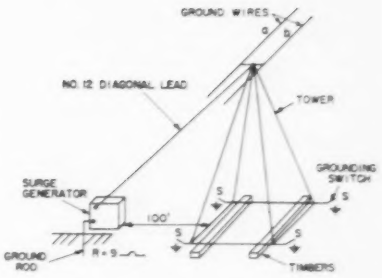

Fig. 6. Schematic diagram of test setup for top-of-tower measurements with diagonal lead.

In the past, some theoretical work and a limited amount of field work was done to arrive at an equivalent circuit representation of the surge response of a tower. Some papers have indicated that there are factors in addition to tower footing resistance which are of predominant importance. It was felt that further work was needed in this regard. In order to meet the problem directly, it was decided to surge a full scale tower. It was felt that certain data would be obtained which would make it possible to construct tower models on which more extensive and variable testing could be carried out to evaluate the effects of tower configuration on the surge response of a tower.

SURGE RESPONSE OF TOWERS

FOR THE PURPOSE of determining the surge characteristics of a 138-kv double circuit tower and the effects of one or two ground wires on modifying these characteristics, a tower was tested as shown in Fig. 4. This test tower was raised mechanically from ground so that impulse surges could be applied at the base of the tower; a measurement of the capacitance of the tower to ground could be made with a capacitance bridge; and the effect of various footing resistances could be evaluated when surges were applied over another lead to the tower head.

The height of the tower including extension was about 125 feet from the ground line to the top where two ground wires were supported. The 134,600-CM (circular mil) ACSR (aluminum cable steel reinforced) ground wires with a horizontal separation of 15 feet were 0.53 inch in diameter. Distance from the test tower to the two adjacent towers was 530 feet and 537 feet. The phase conductors were 477,000-CM ACSR with a diameter of 0.858 inch.

After the tower was raised, it was supported by timbers with insulating boards between the timbers and the steel. Thus, the tower was insulated from ground so that ground connections would be made as desired during the investigation. As shown in Fig. 4, Manila rope guys were applied to the tower when it was lifted from its normal position.

Some tests were made at the ground line within the base of the tower as located in Fig. 5. Other measurements were made from a point 100 feet from the base of the tower at right angles to the direction of the line conductors as shown in Fig. 6. Still another group of measurements were made from a position 200 feet from

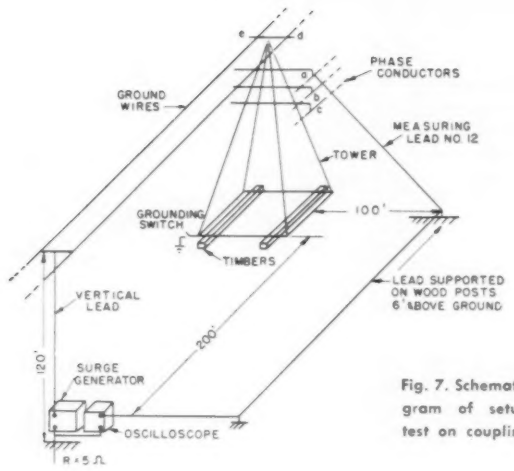

Fig. 7. Schematic diagram of setup for test on coupling.

the base of the tower and directly below the overhead ground wires as shown in Fig. 7.

The surge studies were made with a miniature impulse generator or Transient Analyzer. This analyzer produces controllable steep fronted waves with relatively long tails. The impulses are repeated at a rate synchronized with the horizontal sweep of a cathode ray oscillograph such that a stationary image is obtained on the screen for visual observation or photography. A photograph of this equipment is shown in Fig. 8.

CAPACITANCE MEASUREMENTS AT BASE OF TOWER

Prior to the study in the field to determine the surge characteristics of the tower, analytical investigations had been in progress on the transient network analyzer in which work was being done on models simulating the tower and its conductors and ground wires. One problem in these analytical studies was the determination of the capacitance to ground of an actual double circuit tower for the purpose of representing it in the model setup. A calculation made by means of flux plots indicated that a typical double circuit 138-kv tower has a total capacitance to ground of 1,200 micromicrofarads (μμf). It was desired to verify the calculated value of capacitance and for this purpose a capacitance bridge measurement was made.

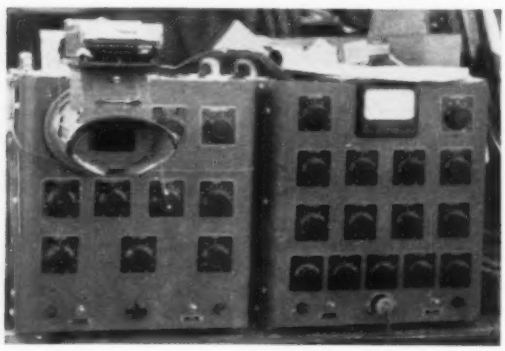

Fig. 8. Photograph of transient analyzer or surge generator used in field tests.

In the Fig. 5 schematic diagram illustrating the capacitance measurement of the tower, a General Radio capacitance bridge was connected between the cross-over point of the No. 12 leads and the ground rod at the center of the base of the tower. A value of 3,500 μμf was measured at a frequency of 1,000 cycles for the tower including the temporary angles and measuring leads. Subtracting out the capacitance of the temporary leads and bracing the measured value of the capacitance of the tower alone was 1,250 μμf. A comparison of the calculated and measured values of tower capacitance shows good agreement.

SURGE MEASUREMENTS AT BASE OF TOWER

It was desired to evaluate the degree of effectiveness of the ground wires in modifying the magnitude of the surge voltages occurring at the top of the tower. For this purpose, the surge generator, shown in Fig. 8, was connected in place of the capacitance bridge, shown in Fig. 5. The generator constants were set so that the reflected wave returning down the tower would see a terminating impedance at *A* of Fig. 5 in the order of 80 ohms in the generator.

Typical oscillographic results of the surge voltages obtained at the base of the tower are shown in Fig. 9. These oscillograms illustrate the effects of connecting to the tower top zero, one, and two ground wires. The initial sliver of voltage seen on these oscillograms is caused by the cross-leads connecting the generator to the legs of the tower.

During the time of occurrence of the first reflected wave from the top of the tower as observed at the base, the total voltage—first outgoing wave plus first reflected wave—for one- and two-ground wires connected to the tower are 79% and 70% respectively, of the voltage with no ground wire. It appears that with both ground wires connected, the reflected wave which finally reaches the base of the tower is approximately zero. The connection of the second ground wire resulted in an additional decrease in magnitude of the reflected wave of 35% of the change obtained by connecting one ground wire.

Estimates of the velocity of propagation of traveling waves in the tower indicate a velocity slightly less than the speed of light. The round-trip travel time of the surge from the center of the base of tower to the top and back again is measured from the initiation of the surge on the oscillograms of Fig. 9 to the point at which the presence of one ground wire produces a deviation from the oscillogram obtained with no ground wire attached to the tower.

SURGE APPLICATIONS TO TOWER STRUCTURE TOP

The surge impedance of the tower is an important parameter in determining the nature of the voltages generated in the tower due to surge currents propagating as a traveling wave in the tower. Surge currents in the tower structure may be caused by a direct stroke to

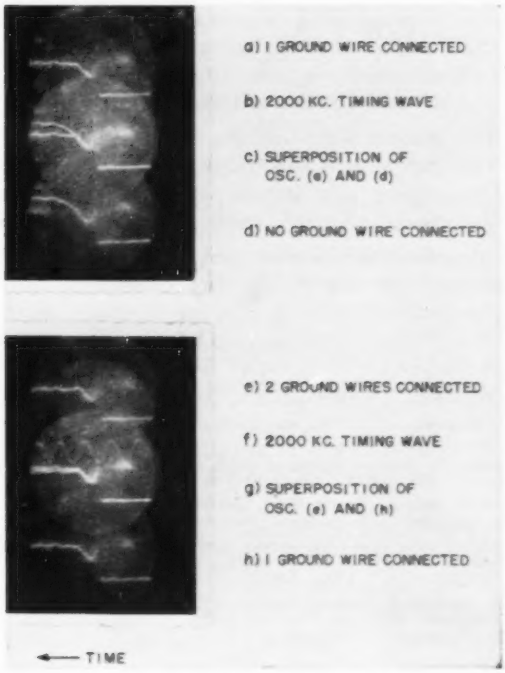
a) 1 GROUND WIRE CONNECTED
b) 2000 KC. TIMING WAVE
c) SUPERPOSITION OF OSC. (a) AND (d)
d) NO GROUND WIRE CONNECTED
e) 2 GROUND WIRES CONNECTED
f) 2000 KC. TIMING WAVE
g) SUPERPOSITION OF OSC. (e) AND (h)
h) 1 GROUND WIRE CONNECTED
TIME

Fig. 9. Oscillograms of surge tests at base of tower.

the top of the tower or to the ground wires at some point removed from the tower.

Applying surges to the top of the tower by means of the diagonal lead from a surge generator at ground level as in Fig. 6, introduces some "lead" effects different from those obtained with a lead oriented horizontally with respect to ground. The surge impedance of the diagonal lead varies as a function of its height above the ground. Thus, as a surge travels up the lead, there are continuous reflections of this outgoing surge returning to the origin and modifying the voltage at the generator from that which would occur if the lead to the top of the tower had a constant surge impedance along its entire length. The effects are to be noted in the oscillograms of Fig. 10, where the diagonal lead was open circuited at the tower end and the impedance of the generator, as seen by the reflected wave returning to the sending or surge generator end, was 715 ohms.

The modifications produced with a diagonal lead were analyzed and are discussed in another paper.[6]

Termination of the diagonal lead to the tower top with the base of the tower grounded and with the base of the tower ungrounded and termination to one and two ground wires having no connection to the tower produced the voltage oscillograms shown in Fig. 11. To analyze these oscillograms as a first approximation, effective values of surge impedance of the diagonal lead were established, one for calculations involving the tower termination and the other for calculations involving the sending end. These values were chosen for the 25% and 75% points on the diagonal lead and are 590 ohms and 655 ohms respectively.

The calculated results for the surge impedances of the tower alone and of the ground-system wires from the oscillograph data are as follows:

(a) 1 ground wire—520 ohms; (b) 2 ground wires—288 ohms; (c) tower isolated—165 to 108 ohms; and (d) tower grounded—165 to 50 ohms. It is evident that the calculated "surge" impedance values of the tower depend upon whether or not the base of the tower is solidly grounded or isolated, and varies from a maximum value of 165 ohms at the start of the first reflected wave from the top of the tower to some lower value at the time the predominant effect of the base is felt through the resultant reflected waves in accordance with the termination of the base of the tower. These differences probably arise from the fact that the fields associated with the first outgoing wave from the generator are established in space with respect to ground and couple the whole tower at the time the surge reaches the top of the tower. It is assumed that these coupling effects produce different results at the tower top dependent upon the degree of grounding. It might be further inferred that for a given surge severity at the tower, those produced by strokes to the ground wires will have a significantly different effect from surges produced by strokes direct to the tower top. For the stroke to the tower top, the electric and magnetic fields associated with the changing current and voltage conditions in the tower top have not been established with respect to ground with a complete coupling of the tower.

With regard to the velocity of propagation of surges in the tower, the results from the oscillograms of Fig. 11 for the grounded tower and for the isolated tower are 905 feet per microsecond (μsec) and 1,040 feet per μsec, respectively.

There can be rates of rise wherein the tower impedance is more nearly characterized by its inductance. For these cases, the foregoing surge impedance values provide a means for estimating the inductance.

COUPLING MEASUREMENTS

To examine the degree of coupling between the phase conductors and the ground wires for traveling

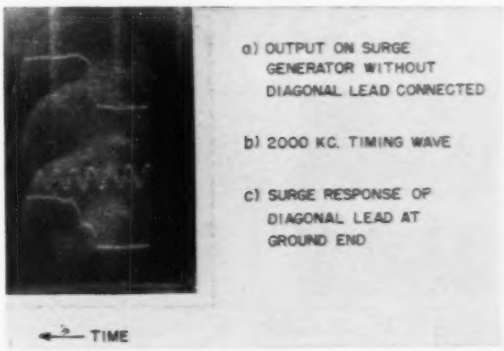
a) OUTPUT ON SURGE GENERATOR WITHOUT DIAGONAL LEAD CONNECTED
b) 2000 KC. TIMING WAVE
c) SURGE RESPONSE OF DIAGONAL LEAD AT GROUND END
TIME

Fig. 10. Oscillograms of the surge response of the diagonal lead of Fig. 6. Lead not connected at top of tower.

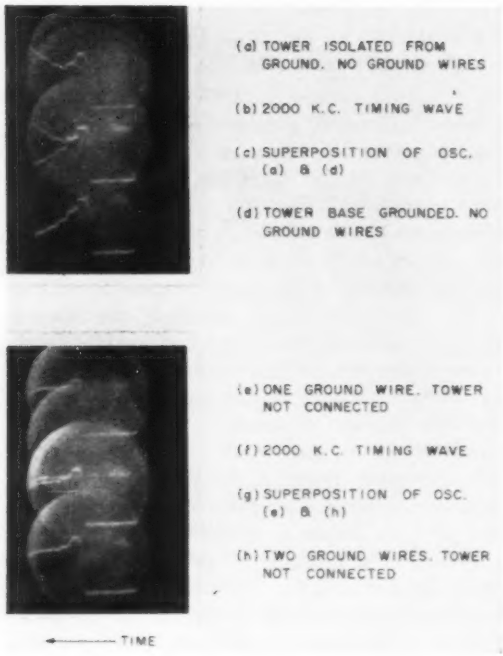
(a) TOWER ISOLATED FROM GROUND. NO GROUND WIRES
(b) 2000 K.C. TIMING WAVE
(c) SUPERPOSITION OF OSC. (a) & (d)
(d) TOWER BASE GROUNDED. NO GROUND WIRES
(e) ONE GROUND WIRE. TOWER NOT CONNECTED
(f) 2000 K.C. TIMING WAVE
(g) SUPERPOSITION OF OSC. (e) & (h)
(h) TWO GROUND WIRES. TOWER NOT CONNECTED
TIME

Fig. 11. Oscillograms of tower and ground wire response for surge applied to top of tower over diagonal lead of Fig. 6.

waves on the ground wires, surges were applied to the ground wires as shown in the schematic diagram of Fig. 7. The ground wires were lifted from the test tower to eliminate the effect of a connection to ground at this location. Oscillograms of the voltages appearing on the ground wires and on the top and middle phase conductors were obtained by connecting the No. 12 conductor measuring lead to points *d*, *a*, and *b*, respectively (Fig. 7). It was assumed that "lead" effects would produce proportional modifications in the measure results. Typical oscillograms of the ground wire voltages and coupled voltages on the phase conductors are shown in Fig. 12.

An occurrence unexplained insofar as the coupled-voltage oscillograms are concerned is the decrease in voltage to zero sooner than and not associated with the decrease in voltages on the ground wires. However, if one uses corresponding instantaneous values of voltages on the rising fronts of the voltages on the ground wires and phase conductors, coupling factors in percent of ground wire voltages are as follows:

1. Two ground wires and top phase conductor—45%
2. Two ground wires and middle phase conductor—30%
3. One ground wire and top phase conductor—29%
4. One ground wire and middle phase conductor—23%

For the case of one ground wire, surges were applied to the ground wire nearest the phase conductors.

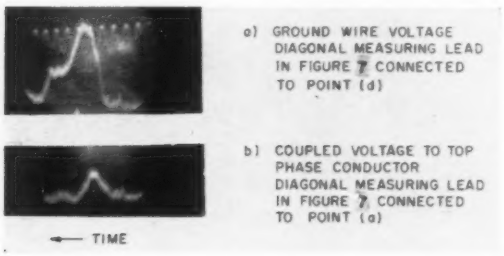
a) GROUND WIRE VOLTAGE DIAGONAL MEASURING LEAD IN FIGURE 7 CONNECTED TO POINT (d)
b) COUPLED VOLTAGE TO TOP PHASE CONDUCTOR DIAGONAL MEASURING LEAD IN FIGURE 7 CONNECTED TO POINT (a)
TIME

Fig. 12. Oscillograms form coupling tests as shown in Fig. 7. Surge applied to two ground wires.

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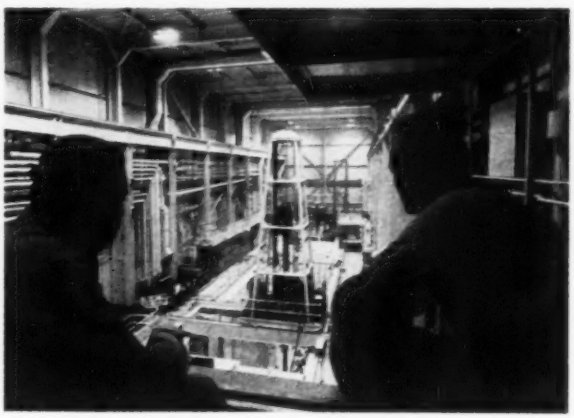
Full-Scale A-Power Station



Twenty-four-hour-a-day preparations for placing into operation the nation's first full-scale atomic-electric generating station have been climaxed now that the plant at Shippingport, Pa., is producing electric power for use in Greater Pittsburgh homes and industry.

Inside the fuel handling canal building is a derrick-like structure which supports a special fuel element extraction tool. When the uranium fuel elements are replaced in the nuclear reactor, they will be handled remotely by this "mechanical hand" and will be kept under water in the area beneath the derrick.

Westinghouse, under contract with the Atomic Energy Commission (AEC), designed and constructed the nuclear portion of the plant. Duquesne Light is operating the entire plant for the AEC.

The Lightning Stroke

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A. R. HILEMAN
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IN RECENT YEARS renewed interest has developed in the effect of lightning on electrical transmission lines. The most vital characteristic of lightning in most methods of calculating its effect is the current measured at the ground terminal. A large amount of data is available about the stroke current crest magnitude and a considerable amount of data is available which covers the time-to-crest of the stroke current. Despite these data there is still controversy over the time-to-crest. Measurements in the region of a microsecond are admittedly difficult. The industry is still seeking new data. In approaching this problem, it was felt that it might be conducive of results to analyze the mechanism of the return stroke and then, from the factors governing the mechanism, try to synthesize the stroke. Perhaps certain limits to the rate of rise could be ascertained. Some of the characteristics of the component factors could be obtained in the laboratory, others by computation. It was with this in mind that the present investigation was undertaken.

Insofar as possible, it was attempted in this investigation to restrict discussions to observed data and incorporate these characteristics into circuit theory, intentionally avoiding the field of the physicist in speculating upon the theory of gaseous discharges in explaining the reasons for the observed results.

With reference to the characteristics of the stroke it is concluded that:

1. Analysis of available data relating to direct observational results of stroke currents indicates that in the region of greatest interest to the transmission engineer, the time-to-crest is about one microsecond or, probably, two microseconds or more.

2. Upward leaders are more likely to develop from towers and ground wires than from level ground. Of these, lengths may be of the order of 25 to 100 feet in the former and only several feet in the latter. At the present state of the art, the conditions under which upward streamers develop is not completely understood and calculations along this line may be questionable. The existence of such streamers have been verified by photographs in a few isolated instances. Furthermore, since the charge lowered by the downward leader increases with the discharge current that is subsequently developed by the charge, the lengths of the ground leaders are longer the greater the subsequent discharge currents.

3. The transient arc characteristics of the return stroke are such as to introduce a series voltage in the arc path that is proportional to the rate of change of current and which, therefore, has the characteristics of an inductance. This inductance together with the natural inductance and the corona capacitance, which is determined by a charge located at a greater radius than the current, helps to explain that the velocity of propagation of the return streamer is less than that of light.

4. Laboratory tests on the corona sheath surrounding a conductor indicate a time lag of the order of 0.1 to 0.2 microsecond. If one extrapolates this time lag to the scale met in lightning, on the assumption that the lateral process of the discharge from the arc to the tapped charge area is by streamer propagation, a time-to-crest of the current of 1 to 2 microseconds or more would result.

5. As the head of the return streamer reaches a particular point, the charge fed into the streamer at that point increases abruptly to half of its final value and then rises to crest more slowly.

6. The fundamental purpose of this investigation was to determine whether the time-to-crest of lightning currents of the order of 20,000 amperes or more are about 0.2 microsecond or greater than 1.0 microsecond. The directly observed data indicate a time-to-crest greater than 1 to 2 microsecond or more. This can be substantiated by assuming that the neutralizing processes in a section of the lightning channel proceed by lateral discharges that grow with about the same speed as spark discharges.

7. While the analysis of some of the component elements of the stroke presented in this paper do not make possible accurate description of the stroke, they do provide an orientation of the relative magnitudes that exist. This refers to such factors as:

(a) The potential of the downward leader.

(b) The charge density distributed along the downward leader.

(c) The length of the upward streamers and the charge density distributed along them.

(d) The transient voltage characteristics of the arc constituting the main discharge channel.

(e) The important factor that determines the rate of rise of current, namely, the rate at which negative charge distributed by the downward leader can be fed into the discharge channel that rises from the ground.

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The Power Application Vacuum Switch

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HONORARY MEMBER AIEE

Vacuum switching, which has attracted considerable attention recently in the public utility field, is actually far from a new concept. Much of the work done over the past 35 years in the development of the vacuum switch is reviewed.

THREE CONCURRENT 1923 influences—a circuit breaker manufacturer's request for aid in developing better circuit breakers, the installation at California Institute of Technology (CalTech) of means for providing vacuum ambients for research programs, and a doubt about the completeness of knowledge regarding electric arc phenomena—synthesized a strong conviction that vacuum ambient power application switches could be made. This article describes the researches that made possible the development of power application vacuum circuit breakers.

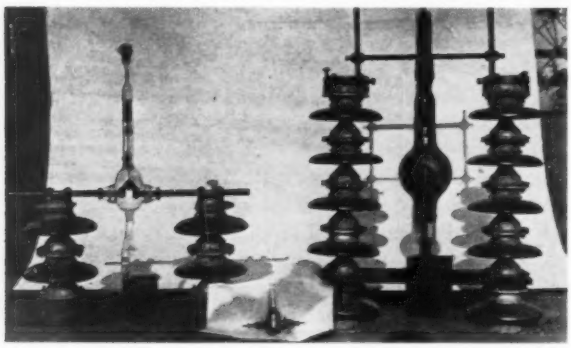

Fig. 1. First experimental power application vacuum switches. In the order of production: (*Center*) thousands of successful operations in free atmosphere at 2,300 volts, and with switch immersed in oil at 15 kv; (*Left*) opened generator short circuits at 13 kv and 600 amperes; (*Right*) under like conditions, interrupted over 925 amperes, short circuits at about 42 kv.

In 1923, the need for a new approach to circuit breaker design was acute. Growing power demands and expanding interconnection programs had reached a magnitude that taxed to the limit the integrity of the best-made circuit breakers.

Two of the many circuit breaker stymies were the production of satisfactory bushings and the provision of maximum dielectric recovery. The spirit that solves such problems is well illustrated by remarks made 15 years before 1923 when one well-known electrical engineer asked another, "How high will you go for transformer voltages?"; the reply was "We will build transformers for voltages as high as any for which you build circuit breakers." The stymie then, which happily no longer exists, was how to make satisfactory 110-kv bushings.

A high-vacuum ambient, if such could be maintained in conjunction with switch-opening arcs, appeared to be the ideal way to provide quick dielectric recovery. Literature searches and discussions with engineers and physicists were quite discouraging, but when the late Dr. R. A. Millikan was asked for an opinion his reply was, "We will try it." A graduate student, H. E. Mendenhall, ran a series of tests and wrote a 1923 research progress report opening with "About October 1, 1923, under the direction of Dr. Millikan the design of a switch to operate in high vacuum, which had been suggested about August 15, 1923, by Professor Sorensen was begun." The report cites success for several hundred interruptions of a-c and d-c currents at 220 volts and for a-c circuits at 2,300 volts with the first successful vacuum switch, the small center item of Fig. 1. When tried at 15,000 volts, this switch arced over outside; but when immersed in oil, it made thousands of successful power circuit interruptions at this and higher voltages. His report also shows some success with fine outgassed copper wire fuses in highly evacuated sealed-off glass tubes. The progress report, a 1926 paper given at Salt Lake City, Utah,[1] and a thesis by Mendenhall,[2] together describe experiments with the three switches of Fig. 1. These experiments[3] disclosed previously unknown arc phenomena and proved that vacuum switches are ideal for a-c circuits because they interrupt the current flow the first time the current value passes through zero. The arc energy is then very small, and the dielectric recovery against restrike is instantaneously very great. The switching arc explosive force which takes place in oil-type breakers and is transmitted to the switch container is absent when vacuum switches open circuits. The observed phenomena at switch openings are the arc, a small quantity of material discharged from the electrodes, and its deposit on the inside surface of the switch housing. This expelled material, it was discovered, occasionally would puncture the contact operating bellows and, even at times, the glass switch containers, unless shielding was provided or unless the glass was strong enough to prevent puncture by particle bombardment.

New arc characteristics which changed the then described arc theory were noted and found useful as guides to improvements in switches of other types dur-

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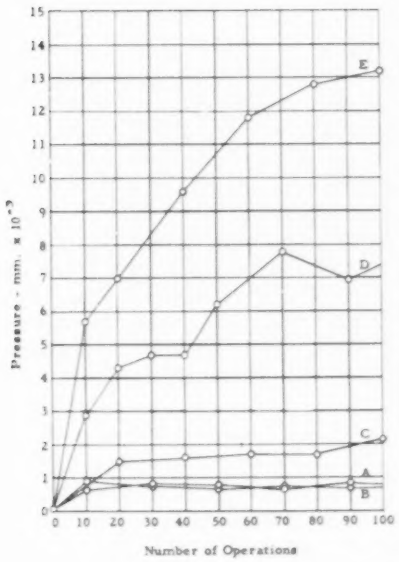

Fig. 2. Vacuum pressure curves, constant voltage 2,300 volts. Current density, amperes per square inch: copper contacts, (A) 3,500, (B) 12,300, (C) 24,000; tungsten contacts, (D) 4,500, (E) 11,250.

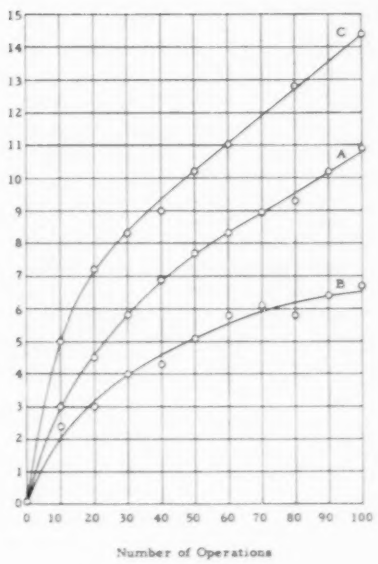

Fig. 3. Vacuum pressure curves, constant voltage 15 kv. Current density, amperes per square inch: copper contacts, (A) 370, (B) 840; tungsten contacts, (C) 450.

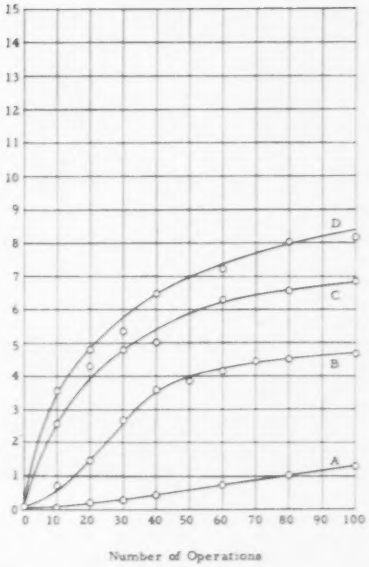

Fig. 4. Vacuum pressure curves, constant electrode current density 150 amperes per square inch. Interruption voltages, kv: (A) 15, (B) 25, (C) 30, (D) 35.

ing the 30-year hiatus between the breakthrough and the acceptance of power application vacuum switches. Computations showed that vaporizing the small amount of electrode material detached from the switch contacts when currents were interrupted could account for very little of the arc energy during interruption. Many interruptions deposited enough material driven from the electrodes on the inner surface of the glass switch containers to make much of them opaque. Thousands of operations, however, did not result in any flashover between switch terminals caused by the deposited material.

The vacuum switches of those researches were made successful by enclosing separable contacts of commercial copper or other metal in high-vacuum chambers and making enough current-interruption arcs while the vacuum was maintained to remove from the contacts the adsorbed gas. Sometimes very few arcs would suffice, and always enough arcs formed a successful vacuum switch.

Perhaps other experimenters who studied arcs *in vacuo* and concluded that vacuum switches could not be made reached that conclusion because of failure to arc the electrodes in vacuum the number of times required to remove from them the absorbed gas.[4]

Vacuum switches conditioned for a given voltage were always successful for voltages up to that value, but use at much higher voltages often required additional conditioning at the new voltage. Vacuum switch contacts once conditioned but by accident exposed to the air, at times as much as 24 hours, were restored to service with a very few switch opening arcs. On some occasions, after a shorter exposure, no new reconditioning was required. This indicated that perhaps absolutely gas-free electrodes could be operable as a vacuum switch without arcing, but the experiments of the breakthrough program did not decide that question.

The large right-hand switch of Fig. 1 in test runs at over 40,000 volts after being broken and open to the air for over 24 hours was again in good condition after one or two switch opening arcings. Apparently identical vacuum switches did not all function in the same way. To eliminate any uncertainty, a test parameter of 100 circuit interruptions was established, because switches operated that often with no failures continued for 1,000 or more operations without failure. This parameter should not be considered the minimum number of operations required to guarantee a stable condition, inasmuch as it was arbitrarily chosen without any effort to determine a true minimum number of required stabilizing operations.

Most of the loads used were low power factor (about 40% lagging). With few exceptions, the resultant switch opening overvoltage was smaller than for oil switches under the same conditions. It was realized, however, that vacuum switches with their quick breaks could result in high voltages when the load involved large energy stored in inductive circuits.

The difficulties encountered were obtaining good vacuum containers, good vacuum gauges, proper pumping equipment, and metal-to-glass seals that were vacuum tight, particularly large cylindrical ones—the only good cylindrical ones being supplied by Bell Telephone Laboratories, Inc.

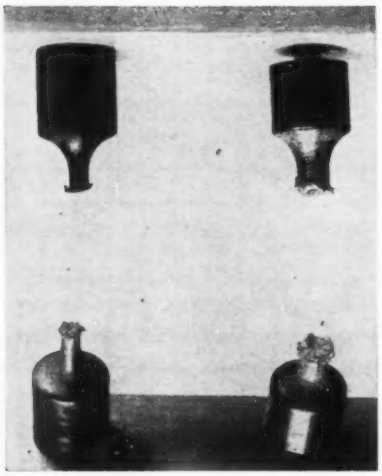

Fig. 5. Vacuum switch contacts which continued to function properly after current heating and mechanical pressure mushrooming.

Vacuum-tight bellows were difficult to obtain but sylphon units selected from commercial lots provided the number required.

Mendenhall's successful experiments were supplemented by the researches of three other graduate students, J. H. Hamilton, C. D. Hayward, and F. C. Lindvall. These four and the author, aided by R. A. Millikan's advice, devoted many hours to vacuum switch research until 1929, at which time the project was taken over by an industrial research laboratory.

Hamilton's thesis[5] describes how, in one phase of his study, he used a magnetic oscillograph and a special circuit arrangement for measuring the low arc voltage, viz., 10 to 20 volts across vacuum switch opening contacts in circuits up to 15,000 volts. Tests on oil switches gave higher arc voltages and arc energies.

The results of two similar tests at low power factor inductive loads were as follows:

	Vacuum Switch	Oil Switch
I_{rms}	58.1 amperes	56 amperes
E_{line}	16.2 kv	16.2 kv
Time	0.008 second	0.05 second
Energy	7.2	552

$$\text{Ratio of energies} = \frac{552}{7.2} = 77 \text{ to } 1$$

This thesis also discusses the then published arc theories as related to Hamilton's tests, and concludes that during arcing the current conduction apparently could not be solely by electrons but must require positive charges. Also, the evidence shows that the emission of electrons from an electrode produces a positive space charge just off the cathode, thus making feasible a large electron emission at low cathode drop. This analysis led to the conclusion that with no gas present in the electrodes, the arc extinction is at or near the time when the circuit current crosses zero value; the voltage reaching its normal value across the open switch with a time lag of about 0.0001 second.

A thesis by F. C. Lindvall[6] contains numerous curves, some of which are reproduced as Figs. 2, 3, and 4. The ordinates of these curves are internal switch ambient pressure in thousandths of millimeters of mercury, the abscissas being number of switch operations. The curves show that the getter action of the detached electrode metal balances the tendency of that metal to soften the vacuum, the metal being deposited as a film on the inner surface of the switch housing. For this study, 100 operations per test were established after numerous tests on switches extended to 1,000 and more operations showed that the greater pressure changes occurred within the first 100 operations. Throughout the college researches, vacuum switching was successful for vacuums ranging from 10^{-2} to 10^{-5} millimeters of mercury. Figs. 2 and 3 show the effect of contact current density at two convenient laboratory circuit voltages. Fig. 4 shows the effects of voltage changes in a switch operating at constant contact current density. These curves show that both current and voltage influence the amount of gas desorption, but before 1931 it was known that single-break vacuum switches could handle voltages ranging up to over 80 kv, and at lower voltages could switch successively currents of over 3,000 amperes.

Fig. 5 shows two pair of switch copper contacts that continued to function successfully even when the current through them produced a softening temperature

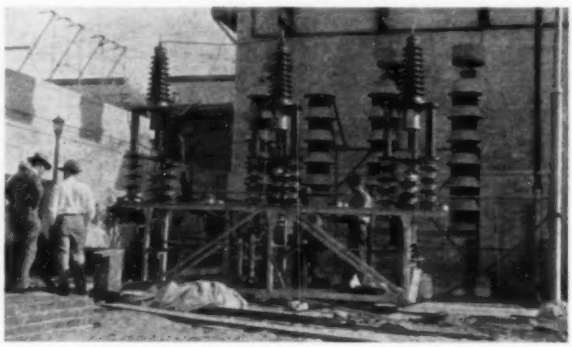

Fig. 6. No-glass 3-phase 60-kv vacuum switch.

that let the contact pressure cause the mushroom effect shown. These and other experiments produced temperature rise evidence that vacuum switches were best suited for interrupters rather than continuous current carriers.

A thesis by C. D. Hayward,[7] the last report by the college vacuum switch research group, confirmed the findings made with the slower writing instruments. Three of the confirmed items were the apparent several time arc energy storage and releases during the brief arc durations, the getter action of expelled electrode particles during circuit openings, and evidence that often the very quick vacuum switch interruptions of inductive circuit currents resulted in lower surge-voltage drops across the opening switch contacts than were produced by oil switches used as alternates in the same

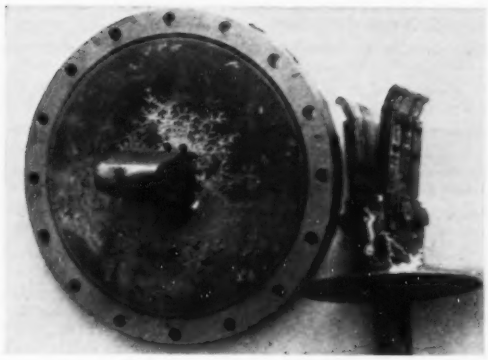

Fig. 7. Contacts used in vacuum switch shown in Fig. 6.

test circuits. Also, this work checked Lindvall's determination that the softer the metal electrode, the more getter action and lower voltage surges at switch openings—aluminum in this respect being advantageous over copper, and copper advantageous as compared to tungsten.

The CalTech program included the production of some 3-phase switches for trial on power systems. Fig. 6 shows a design influenced by the success of large high-voltage X-ray tubes made of metal and porcelain. The joints were made vacuum tight by aluminum O-ring seals. The switch, as constructed, included a vacuum pump. The performance of this switch was erratic, with some successful switch openings interspersed with failures. Fig. 7 clearly shows the fault. The large amount of conditioned metal around the switch contacts made complete desorption of the gas impractical, so that when the arc of interruption reached a place not outgassed, the switch would not open the circuit. The collar on the movable electrode is a shield to prevent expelled particles from puncturing the copper bellows used to permit movement of the electrode. Experiments with high enough voltage and no current produced cold emission bombardment that punctured glass and bellows. Fig. 8 shows the Fig. 7 switch reconstructed with glass vacuum-tight housing protected by porcelain covers. Fig. 9 shows more clearly one pole of this arrangement. One criteria for this change was the determination by both Mendenhall and Lindvall that small interior volumes were preferable because the smaller volumes contain fewer particles, the agglomeration of which tends to produce conduction. The natural emigration from CalTech (via the PhD route) of Mendenhall (1927), Lindvall and Hamilton (1928), and

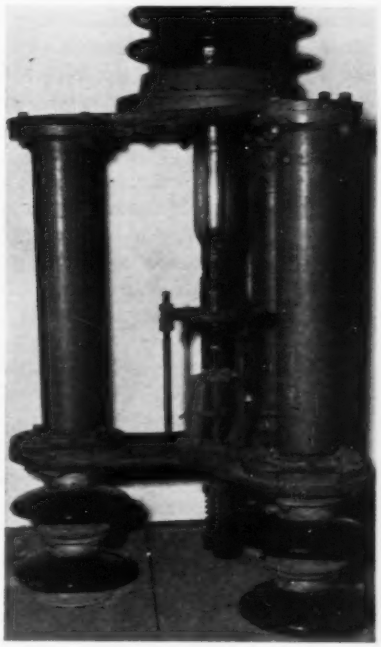

Fig. 9. Vacuum switch in glass housing and flexible bushing entrance detail.

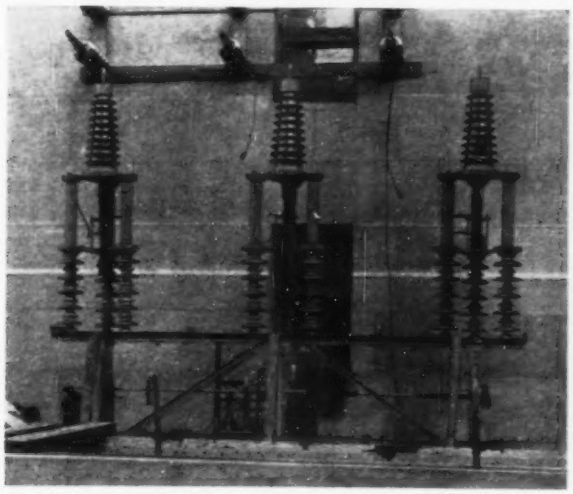

Fig. 8. Vacuum switch as shown in Fig. 6 rebuilt using glass contact enclosures.

Hayward (1929), together with the transfer of the vacuum switch project to an industrial research laboratory, concluded the breakthrough.

The only American paper about power application vacuum switches between 1926 and 1955 was presented by R. Koller[8] at the AIEE Summer Convention at Detroit, Mich., in 1946. That paper described experiments with a small vacuum switch in many ways similar to Lindvall's. The Koller experiments confirmed the earlier results and added new information. The two basic differences between the Koller experiments and those forming the basis of this paper are that Koller used d-c, whereas this paper is based on all a-c experiments with the exception of the first vacuum switch trials made by Mendenhall and Otis with d-c. Vacuum switch d-c and a-c performance differ because d-c has no current zero time.

The hiatus period, made much longer than it otherwise might have been by the lean economic 1930-40 decade, was not devoid of vacuum switch interest. T. E.

Browne, Jr., who discussed Koller's 1946 paper,[8] compiled in that year a history of the vacuum switch for the Westinghouse Electric Corporation.[9] This cites small current switch usage and a number of successful large current operations between 1923 and the 1955 breakthrough, but shows no power system usage.

In 1955, tests on the 230-kv lines of the Bonneville Power Administration system[10, 11] resulted in the return of the power application vacuum switch creation to the Pacific Coast. In 1955, a description of years of vacuum switch continuous service in the shops of the Jennings Company[12] foretold an acceptance for power application switches, a prophecy which was forceably confirmed by three more recent AIEE papers.[13-15]

Fostered by the Jennings Radio Corporation and the Schwager Wood Corporation, the vacuum switch, by virtue of the vacuum technique knowledge gained during a 30-year time lag, has become the choice for hundreds of power system applications. Continued research and development will no doubt greatly increase the scope of their applications.

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Fuse-Monitoring System for Multiple Fuse Circuits

G. R. LEZAN

A circuit is described which will automatically provide an electric signal each time a power fuse blows, and also will provide a second distinct electric signal after a predetermined number of fuses have operated in a group of parallel cells.

RECTIFIER CELLS in power semiconductor rectifier equipments are connected in parallel whenever it is desired to obtain output-current ratings exceeding the single-cell circuit rating. In practice, thus far, as many as 32 cells have been operated in parallel. In order to protect the rectifying equipment in the event of a rectifier cell failure,* power fuses are used in series with each cell or a pair of cells. When a cell failure occurs, the resulting short-circuit current interrupts the power fuse and, thus, the defective cell is disconnected from the circuit. The removal of a cell from the circuit represents the removal of a forward-conducting path from the group of parallel cells and results in an increase of current in the remaining cells of the group. The relative increase of current will depend upon the number of cells in parallel in the group. The greater this number, the smaller the relative current increase will be in each of the remaining parallel paths. When a cell failure occurs, depending upon the situation, it may or may not be necessary to remove power from the circuit and replace the defective cell in order to avoid current overload damage to the remaining cells.

* The term "failure" of a semiconductor rectifier cell as used in this article refers to a complete loss of the rectifying properties of the device. For all practical purposes, it is said then that the cell offers negligible opposition to electric current of either polarity.

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Assuming for the present that a usable signal is available each time a fuse blows, the question arises as to what should be done with this signal. If the signal is used to actuate an alarm, the decision of whether to trip or to keep going will be left entirely to the operator. Even though the right decision may be made each time, the length of time taken to reach the decision may be sufficiently long to result in damage to other cells in the circuit. An alternative would be to use the signal to trip off the installation each time a fuse blows. Although this would be the safest approach under these conditions, users will often object to the interruption of output power from their rectifier equipment. In certain industrial processes, interruption of power may result in considerable expense to the user. Thus, the signal should be used to trip the rectifier, but only if a point is reached at which the remaining cells in the circuit are not capable of safely carrying the current overload caused by the loss of parallel conducting paths

REQUIREMENTS FOR A FUSE-MONITORING SYSTEM

SEMICONDUCTOR POWER RECTIFIER EQUIPMENTS are usually designed for 3-phase application. The circuits most commonly used are the 3-phase double-Y and the 3-phase bridge (double-way) configurations. Fig. 1 shows a typical 3-phase double-Y rectifier circuit, with the power fuses in series with the cells. For simplicity, only phase $R5$ has been depicted.

The current-limiting properties of single-crystal semiconductor rectifiers are negligibly small. The cell current is determined for all practical purposes solely by the rectifier circuit parameters such as voltage, reactance, and load characteristics. This property is significant when the loss of a parallel conducting path is considered. Not only will the total output current of the rectifier circuit remain practically unaffected when this occurs, but also the current in the cells in the other phases will, for all practical purposes, remain the same. Thus, only the remaining cells in the parallel combination where a fuse is lost will see an increase in current. If this increase in current is tolerable, then subsequent loss of the same number of parallel paths in all the remaining phases will be equally tolerable.

The requirements for a fuse-monitoring system can now be listed as follows:

1. The system must be able to distinguish the conditions in each rectifier phase independently of the conditions in the other phases.

2. An electric signal must be provided whenever a fuse is blown in any phase in the circuit. This will be referred to as the "warning" signal.

3. An electric signal distinct from the warning signal must be provided each time a preset maximum number of fuses is lost in any one of the distinct groups of parallel cells (phases). This will be referred to as the "trip" signal. The number of fuses permitted before the trip signal is provided should be adjustable to conform with the rectifier circuit conditions.

4. A means shall be provided to identify quickly the physical location of a blown fuse, after the warning signal is given. This requirement becomes more and more important as the total number of fuses in a circuit increases. As many as 96 fuses may be found in a single rectifier circuit. If several rectifier circuits are used side by side in the installation, then the task of identifying a blown fuse quickly may be quite difficult.

5. In the event of failure of any of the fuse-monitoring components, the trip signal should be immediately provided. In other words, the system should be fail-safe.

There are commercially available low-current fuses that have at one end of the fuse cartridge a small spring-loaded plunger that is released when the fuse blows. These fuses will be referred to as "trigger fuses" in this article. The plunger of the trigger fuse may be made to strike a contact bar and close a secondary electric alarm circuit whenever the fuse blows. If the trigger fuse current rating is sufficiently low, compared with the power fuse current rating, and if the trigger fuse is connected in parallel with the power fuse and the latter blows, it will cause the trigger fuse to blow and the plunger will strike the contact bar giving an alarm signal.

A refinement of this method consists of a special fuseholder with an indicating light. This is referred to as an indicating fuseholder and is available commercially. Whenever the trigger fuse blows, the plunger establishes an electrical path to the indicating lamp, thus providing a circuit through which the lamp may be energized. If the assembly is physically located near the power fuse, the indicating light will provide quick visual indication of the location of the blown fuse. Fig. 2 shows the electrical diagram of the indicating fuseholder. The system described in this article uses the indicating fuseholder as the means of providing both visual indication and a usable electric impulse to the fuse-monitoring circuit.

THE FUSE-MONITORING CIRCUIT

INCANDESCENT LAMPS, because of the high operating temperature of the filament, have a hot resistance that

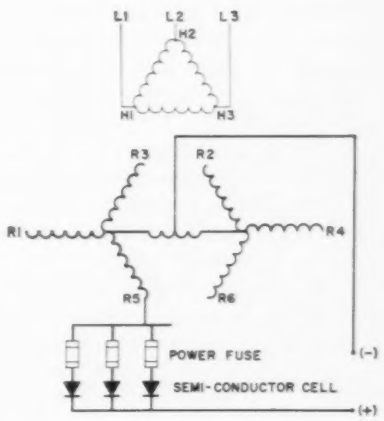


Fig. 1. Delta 6-phase double-Y power rectifier circuit. For simplicity, only three rectifier cells are shown.

is four to five times their cold resistance. When voltage is applied to an incandescent lamp, an initial current surge of peak magnitude four or five times the lamp steady-state current is observed. The current surge decays to 200% of the lamp steady-state current value in approximately 30 milliseconds. This property of the incandescent lamp is used to provide the signal that operates the fuse-monitoring circuit. Fig. 3 shows the input circuit with the sensing relay *58Y*.

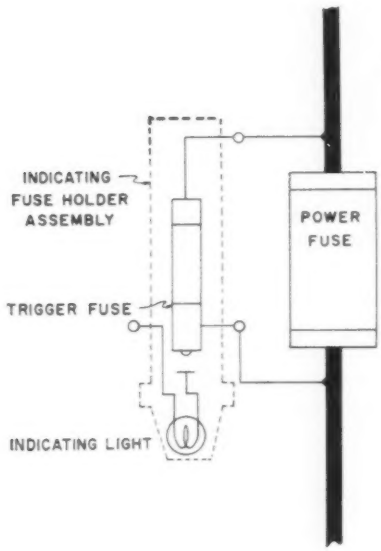


Fig. 2. Indicating fuseholder, internal diagram and connection to power fuse.

The bridge-type circuit used requires a d-c supply. This also permits the use of the semiconductor cell forward conduction as part of the lamp circuit (and thus provide a common return to all lamps regardless of the fuse location). The lamp circuit, including the semiconductor cell, is shown dotted in Fig. 3. Inasmuch as the lamp will be energized only when the power fuse is blown, the cell will not be passing power current when the lamp is conducting. The use of the cell forward conduction is based on the premise that if a semiconductor cell fails, it will fail always in short circuit. Experience has indicated this to be true.

Resistors *R1* and *R2* are chosen so that V_{ad} is approximately half of voltage V_{cd}. When there are no blown fuses and, therefore, no indicating lamps in the circuit, V_{cb} is zero, if the diode leakage current is neglected. When a power fuse blows, causing an indicating lamp to be connected from *b* to *d*, the initial current surge results in forward conduction of diode *CR* and relay *58Y* is energized. As the lamp filament reaches steady-state temperature, V_{cb} decreases and finally becomes less than V_{cd}. This causes current to cease in the relay coil and *58Y* is de-energized. If additional power fuses blow, the addition of lamps in parallel from *b* to *d* will cause relay *58Y* to be momentarily energized each time a lamp is turned on. A point is reached, therefore, when the combined steady-state current of the lamps in parallel is such that V_{cb} remains larger than V_{cd}. Relay *58Y* will then remain energized. By careful selection of the value of *R3*, the relay can be made to provide a pulse for the first lamp and remain energized for the second lamp, or provide a pulse for each of the first two lamps and remain energized with the third lamp, and so on. As the number of warning pulses desired is increased, however, the selection of *R3* becomes more critical because of the increasingly smaller relative current increase resulting from the addition of one more lamp to the parallel group. In practice, the maximum number of warning pulses selected is three and the relay remains energized on the fourth light. This provides sufficient range for the present industrial rectifier equipment ratings and, at the same time, affords consistent reliability in the production of the panels, by allowing for normal tolerances in the resistor, relays, and lamp characteristics.

Fig. 4 shows the complete fuse-monitoring circuit for use in a 6-phase rectifier circuit. Six independent sensing circuits are used, one for each rectifier phase. The six normally open contacts of the *58Y* relays are connected in parallel in the *58W* relay coil circuit. Each time a power fuse blows, relay *58W* is momentarily energized. This relay is designated as the warning relay and panel output terminals for the relay contacts are provided for connection to an external alarm circuit.

The normally closed contacts of relay *58W* connected to *R4* are placed in series with the coil of relay *58D*. Resistor *R4* and capacitor *58C* are used to provide time delay pick-up and drop-out for relay *58D*. The time delay drop-out is approximately 100 milliseconds and was chosen so that the momentary operation of *58W* will not cause relay *58D* to drop out.

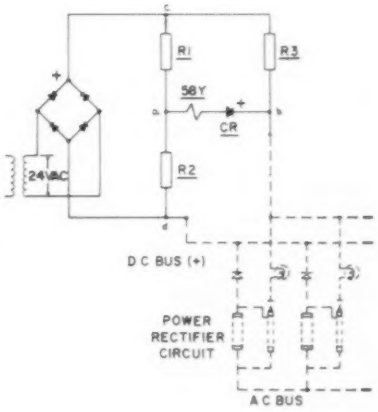


Fig. 3. Single-bridge portion of the fuse-monitoring circuit. Remainder of the circuit was omitted for simplicity.

If the maximum permitted number of lost fuses is reached in any of the rectifier phases, the corresponding relay *58Y* will remain energized. This will cause *58W* to pick up and remain energized. After capacitor *58C* has discharged through the *58D* coil, relay *58D* drops out. Output panel terminals are provided for the contacts of relay *58D* for connection to the rectifier equipment trip circuit.

After the trip signal is generated and power is removed from the rectifier equipment, the indicating lights and the warning and trip signals will remain on, as long as the transformer *58T* is energized and the blown trigger fuses have not been replaced.

If transformer *58T* is de-energized while the power fuses and defective cells are being replaced and if any of the blown trigger fuses are accidentally overlooked and not replaced, the circuit will still provide a trip and alarm signal when transformer *58T* is again energized. This is accomplished by means of the normally closed contacts of relay *58D* in parallel with *R1* and the time delay pick-up provided by *R4* and capacitor *58C*. This feature assures that once a trip signal is generated, this trip signal will be removed only if all blown power and trigger fuses have been replaced. This implies, of course, replacement of the corresponding failed cells. Thus, this system prevents accidental operation of the equipment under excess overload caused by loss of parallel conducting paths.

tive lamps will be located in the same phase is as follows:

$$\frac{8}{48}\times\frac{7}{47}=\frac{7}{282}$$

The probability that any two given lamps in a certain phase be called upon to operate in succession will be

$$\frac{1}{8}\times\frac{1}{7}=\frac{1}{56}$$

Thus, the total probability that two defective lamps in the circuit happen to be called upon to operate in succession is

$$\frac{7}{282}\times\frac{1}{56}=\frac{1}{2,256}$$

or, in other words, one chance in 2,256. The probability of having two burned lamps in the equipment is unknown, however, and will be somewhat related to the average age of the lamps in numbers of hours of operation, and the operating conditions imposed for the lamps.

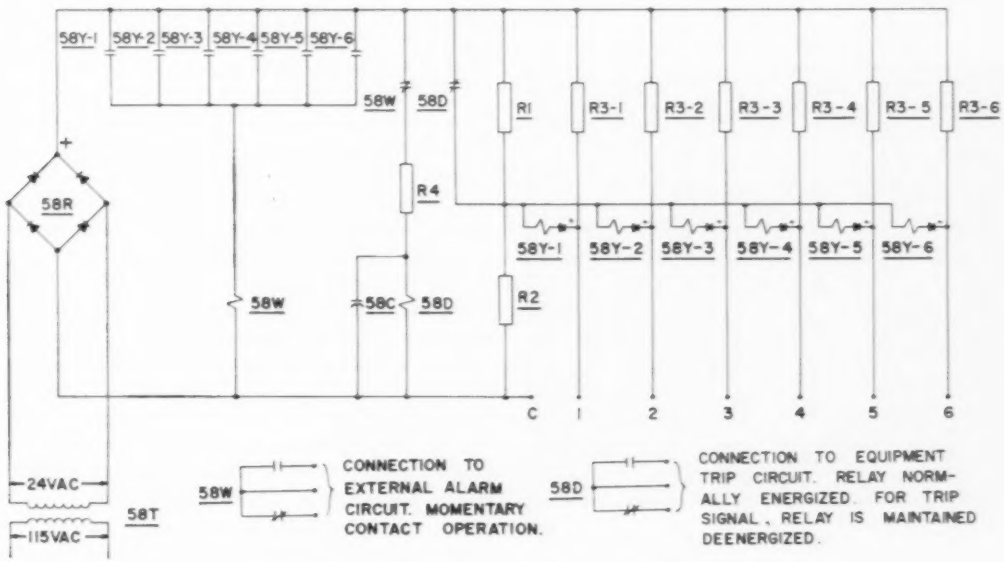


Fig. 4. Complete fuse-monitoring panel with six independent bridge circuits for use with rectifier circuits, such as shown in Fig. 1.

The question of reliability of the filament lamps must be considered. If the filament of a lamp is burned out, the sensing circuit will not be signaled when a fuse blows. Although this at first may seem a serious limitation, there are extenuating circumstances such as lamp derating, low probability of misoperation, and regular maintenance that actually make the chances of trouble rather remote.

As an example, assume that two burned lamps are present in the equipment and consider the probability of lamps being called upon to operate in sequence. Assuming a circuit containing 48 lamps, that is eight lamps per phase, the probability that any two defec-

The indicating lamps are energized only when the corresponding fuse blows. To increase the useful life of the filaments, the lamps are operated below their rating. Resistor *R3* limits the lamp current and under extreme circuit conditions when *R3* is set for a trip on the fourth light per phase, the first light to be energized will be operated at 65% of its rating. In any other conditions, the lamps are operated below this figure.

Occasional testing of the lamps is recommended as part of the regular equipment maintenance. This should be done by low-current continuity testing to avoid undetectable damage to the lamp filaments during the test.

Intermediate Gas Turbine Pumping Units of Trans-Arabian Pipe Line Company

P. P. NIBLEY

A. Y. HILLMAN, JR.

The design requirements of unattended gas turbine pumping units in the Arabian desert under supervisory control from bases 50 to 90 miles away posed a heavy engineering challenge. The novel problems and their solution are described.

TRANS-ARABIAN Pipe Line Company (Tapline) owns and operates a 30- to 31-inch pipeline which transports Arabian crude oil from Qaisumah, Saudi Arabia, to a tanker loading terminal on the Mediterranean coast near the ancient Phoenician port of Sidon, Lebanon (Fig. 1). The pipeline is 754 miles in length and has a present capacity of 340,000 barrels per day.

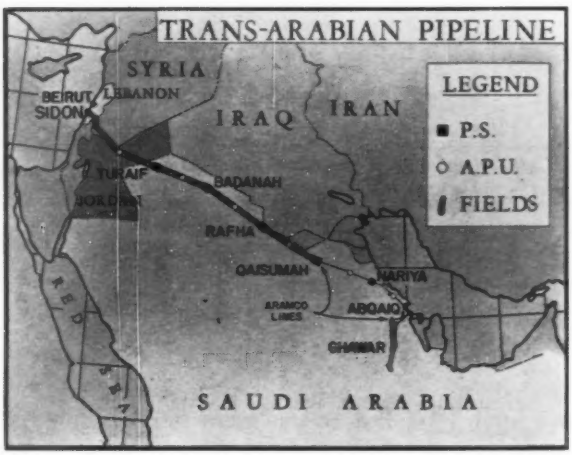


Fig. 1. Route of Trans-Arabian pipeline.

The line has four diesel engine driven pumping stations spaced about 160 miles apart. Each station is a complete community in the vast barren Arabian desert. The desert climate is characterized by extremely low rainfall and summer temperatures reaching 120 F.

The aerial photograph (Fig. 2) gives an impression of the extent of the facilities at a typical diesel pump station. The installation includes housing for 80 to 250 employees, a community center with a dining hall, commissary, movie theater, and other recreational facilities, warehouses, garage, shops, hospital, and the main pumphouse and oil-handling facilities. Each station has its own water supply and complete utility system. Water is available only from wells, some of which are over 1,000 feet deep and require expensive deep-well pumping systems.

AUXILIARY PUMPING UNITS DESIGN

THE PIPELINE was initially constructed in such a way that it could accommodate four additional pump stations at intermediate locations. However, the tremendous investment and relatively high operating costs of complete community stations made this type of station economically unattractive for the intermediate sites. After a careful analysis of a number of alternatives, it was concluded that the most attractive scheme to increase capacity would be to install a single 5,000-hp unattended auxiliary pumping unit at each intermediate location. The installations would consist only of the bare minimum facilities for pumping oil. With this type of unit at the intermediate sites and with additional pumping facilities at the main stations, the capacity of the pipeline would be increased to 450,000 barrels per day—the largest capacity of any long-distance single crude-oil pipeline in the world.

The design requirements for a 5,000-hp unattended pumping unit posed a considerable challenge for the engineers. First, the pumping unit should be powered with a single dependable prime mover. Second, the prime mover should be fueled with crude oil taken directly from the pipeline. Third, the pumping unit should be suitable for unattended operation with supervisory control from base stations 50 to 90 miles away. Fourth, the pumping units should be portable to permit rotation and overhaul at a central shop.

A review indicated that a simple-cycle combustion gas turbine was the only prime mover which would fill these unique requirements. A specification was prepared calling for the pumping units to be portable, completely prefabricated, and factory-tested. The unit would then be shipped to Arabia, hauled overland to the job site, slid onto a concrete foundation, and connected to pump oil. The International General Electric Company was the successful bidder for supplying all the pumping units. These units have now been manufactured, tested, and exported; two are in operation and the balance should be installed by the end of November.*

Essentially full text of an AIEE conference paper presented at the Petroleum Conference held in Philadelphia, Pa., Sept. 9-11, 1957.

P. P. Nibley is manager of operations, Trans-Arabian Pipe Line Co., New York, N.Y. A. Y. Hillman, Jr., is systems application engineer, General Electric Company, Schenectady, N. Y.

*EDITOR'S NOTE: All turbine units were in operation by late November, 1957, except the two permanently mounted turbine-driven pumps at Turaif, Saudi Arabia, which are scheduled for completion in February, 1958.

Tapline will have three auxiliary pumping units on its system and Arabian American Oil Company will have two units on its line feeding Qaisumah. One spare will be available for the five operating units. In addition, Tapline will install a permanently mounted turbine unit at an existing camp in Jordan and two permanently mounted turbine driven pumps at existing stations in Arabia. The total investment by both companies for these facilities will be about $21 million.

The design and manufacture of these pumping units involved considerable pioneering. This is the first time that gas turbines have been installed for continuous operation burning crude oil fuel. This is the first time that a main line oil pump has been directly connected to a gas turbine; the pump turns at 5,200 rpm. This is the first time that a complete 5,000-hp pumping unit has been prefabricated and made wholly portable. Also, it is believed that this is the first time a gas turbine pumping unit has been operated by remote control.

BASIC DESCRIPTION

To obtain these features, a design was chosen which consists of two basic enclosures for station equipment plus a third enclosure for the communications equipment (Fig. 3). Each of the first two enclosures consists of a 36-inch I-beam underframe which acts as the basic mounting floor and supporting structure for the equipment, as well as the basic structure for oil tanks, water tanks, and much of the associated station equipment. The siding and overhead enclosure for the cab consists of aluminum panels mounted on a structural steel framework. The panel sections consist of an external sheet of corrugated aluminum with an internal sheet of flat aluminum. Between these two members are approximately 2 inches of insulation. The panels are made up in approximately 4-foot widths for ease of removal for maintenance.

The third enclosure is shown in Fig. 4, housing the communication equipment, and small auxiliary diesel generator set. This enclosure is a modified enclosed trailer of a tractor–trailer unit and is suitably partitioned and insulated so that the radio equipment section can be air conditioned.

A simplified plan view arrangement of the gas turbine pump enclosure is shown in Fig. 5. Approximate outside dimensions of the enclosure are: length, 53 feet; width, 15 feet; and height, 18 feet. Between the gas turbine and pump is a fire wall. The pump room is designed electrically to meet Class I, Group D, Division 1 requirements. The turbine room is designed to meet Class I, Group D, Division 2 requirements. The pump room is maintained at a slightly negative pressure referred to atmosphere by means of a fractional hp exhauster fan; the turbine room is maintained at a positive pressure by means of an axial vane type room pressurizing fan driven by a 10-hp a-c motor. The gas turbine is a two-shaft simple-cycle unit, rated at 5,000-hp shaft output at 110 F at 2,600 feet altitude. The gas turbine operates on crude oil taken from the pipeline and treated with additive at the site. The additive system and fuel oil system are contained within the unit and are both automatically co-ordinated with the operating cycle.

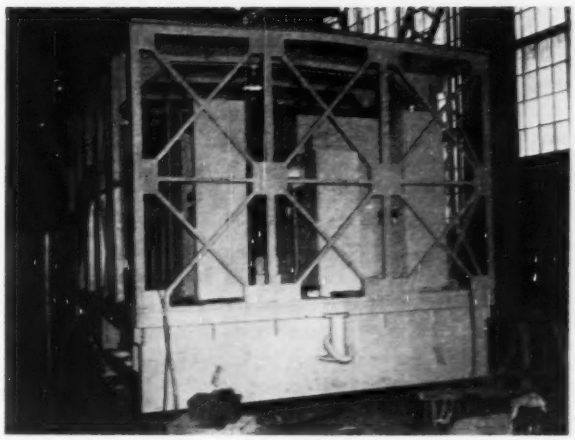


Fig. 3. View of frame of control cab.

The turbine is started by means of a 200-hp diesel engine with torque converter drive. The engine is coupled to the gas turbine through a jaw type clutch which automatically disengages when the gas turbine reaches self-sustaining speed. The main crude-oil pump is driven directly at gas turbine speed (5,200 rpm). The pump is an extremely compact unit—over-all length 5 feet 1 inch, maximum width 4 feet, maximum height 4 feet, weighing 4,650 pounds; prorated on a hp basis, the pump weighs less than 7/8 of a pound per hp, which is quite an achievement in itself. The turbine, in addition to driving the main crude-oil pump from the load turbine shaft, also drives a 125-kva generator from the gas generator set shaft. This generator supplies electric power for the entire station when the gas turbine is operating. The cooling water temperature for the gas turbine lube oil system and turbine shell is maintained by circulating the water through two fin-fan units. Air is circulated through these units by two fans driven by 20-hp a-c motors. During cool-down of the unit, an auxiliary 5-hp d-c fin-fan unit is used. The over-all weight of this cab including all equipment is approximately 125 tons.

Fig. 2. Aerial view of typical diesel pump station installation.

A simplified plan view of the control-filter enclosure is shown in Fig. 6. The cab is similar in construction and has about the same dimensions as the turbine-pump enclosure. The section of the enclosure containing the inlet air filter is open on top to admit the air for the gas turbine, and ventilating air for the turbine and control rooms. The inlet air filter element is a rotating screen type filter with oil bath reservoir at the base of the filter. On the other sidewall of this enclosure is the station battery and the fire extinguisher system. The remainder of this unit is enclosed at both top and sides, and contains the basic control panels for the station. This room, like the turbine room, is operated at a slight positive pressure to prevent leakage of dust into the cab. Mounted in this room is the station auxiliary panel which contains the electrical switchgear, motor starters, and control relays. Also mounted in this room is the turbine control panel, process control panel, and remote supervisory control panel, as well as an inductrol and phanochargers for supplying charging current to the battery. Located between phanochargers and inductrol units is a 10-kva inverter used to supply constant frequency a-c power to some of the instruments, and as the basic power supply for the communication system.

ELECTRIC POWER AND CONTROL SYSTEMS

A SIMPLIFIED ONE-LINE SCHEMATIC of the electrical power system for this station is shown in Fig. 7. It consists of 125-kva, 480-volt, 3-phase, shaft-driven generator which supplies a 480-volt bus. This bus, in turn, supplies power to the motors that operate the ventilating fans, fin-fan units, cooling water motors, fuel treatment motors, auxiliary lube pump motor, and some fractional hp accessory drive motors. The generator also supplies power through a transformer to a 208/120-volt, 3-phase, 4-wire system. This system feeds the lights and essential

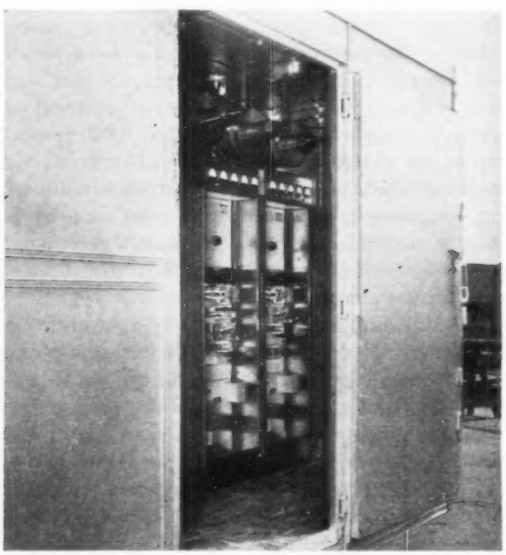


Fig. 4. Enclosure housing the communication equipment and small auxiliary diesel-generator set.

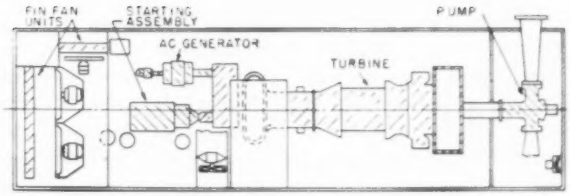


Fig. 5. Plan view arrangement of turbine pump enclosure.

services of the station, as well as the battery charging system, when the gas turbine is not in use. Because of variation in ambient temperature and load requirements of the line, the gas turbine shaft driving the generator may vary in speed by approximately 20%, causing comparable frequency variation. To avoid damage to the motors a regulator is connected into the electric system for varying the generator field in order to maintain a constant volt per cycle relationship over the required speed range. This regulator also acts in a direction to increase field during the station starting cycle when the large a-c motors are automatically started to avoid severe voltage dips.

The station battery which is an 800 ampere hour, 125-volt nickel cadmium battery, supplies power for two basic functions. First, it supplies power to an inverter, which furnishes the constant frequency a-c source for communications equipment and some essential electrical instruments and, second, supplies power to emergency and start-up motors before the gas turbine shaft driven generator is brought up to speed and during shutdown of the gas turbine. A small 30-kw auxiliary diesel-generator set is used to supply power to the 208-volt bus to maintain lights and essential services at the station, as well as to maintain charge on the battery when the gas turbine is not in operation. Once the gas turbine shaft driven generator comes up to speed, the breaker to this generator is opened and the unit is automatically shut down. If the auxiliary diesel-generator set is temporarily out of service, the station battery, fully charged, is capable of supplying power for approximately three complete start-ups and shut-downs of the gas turbine.

The schematic routing of a control signal initiated from the master supervisory control panel is outlined in Fig. 8. This panel will be located some 50 to 90 miles from the operating unit at one of the existing permanent pump stations. The supervisory control system is an all-relay space code selector type system. The signal from the master station first goes to a tone unit causing a frequency shift of the tone. The signal from the tone is sent via vhf radio channel to the location of the operating unit. The signal, upon being received at the operating station, goes through a reverse process first through a tone, then back to a space code which actuates relays in the remote supervisory cabinet to send the proper signal to the turbine control panel. When the signal is received by the remote supervisory, it sends a signal back to the master supervisory, indicating that the information has been received. Also, when the sig-

nal has been complied with by actuation of the proper devices in the turbine control, another signal is sent back to the master supervisory and indicates that the required action has been complied with. Once the unit is in operation, if the operator at the master supervisory wishes to change process conditions by increasing or decreasing the speed of the turbine pump set, the signal (by similar transmission) goes to the process control. The process control, in turn, resets the turbine control to

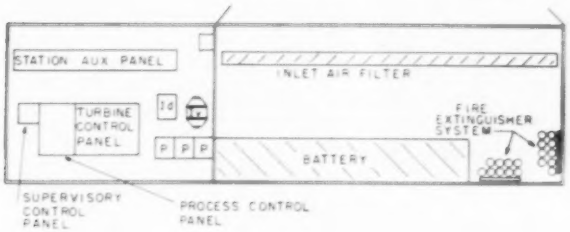


Fig. 6. Plan view arrangement of the control-filter enclosure.

establish a new speed setting. In addition to the supervisory control, there are four telemeter functions: namely, ambient temperature, pipeline discharge pressure, suction pressure of the pipeline at the auxiliary station, and discharge pressure set point which is the basic process control function. Each of these four telemeter functions is continuous. The telemeters are frequency type telemeters and their signal is sent to a tone control which causes frequency shift of tone. The signals, in turn, are sent out from the process control via

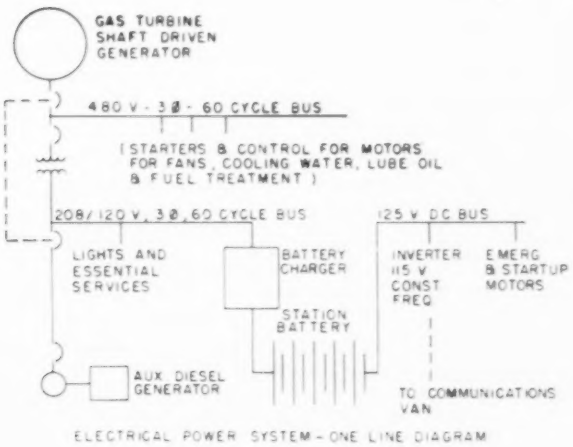

GAS TURBINE SHAFT DRIVEN GENERATOR
480 V - 3Ø - 60 CYCLE BUS
(STARTERS & CONTROL FOR MOTORS FOR FANS, COOLING WATER, LUBE OIL & FUEL TREATMENT)
208/120 V, 3Ø, 60 CYCLE BUS
125 V DC BUS
LIGHTS AND ESSENTIAL SERVICES
BATTERY CHARGER
INVERTER 115 V CONST FREQ
EMERG & STARTUP MOTORS
STATION BATTERY
AUX. DIESEL GENERATOR
TO COMMUNICATIONS VAN
ELECTRICAL POWER SYSTEM - ONE LINE DIAGRAM

Fig. 7. Electrical power system—one-line schematic.

radio channel to tone and telemeter receivers in the master supervisory. Instruments are provided on the face of the master supervisory panel which record the suction, discharge pressure, and discharge pressure set point and indicate the ambient temperature at the station. The radio equipment consists of two vhf channels designed so that supervisory and telemetering informa-

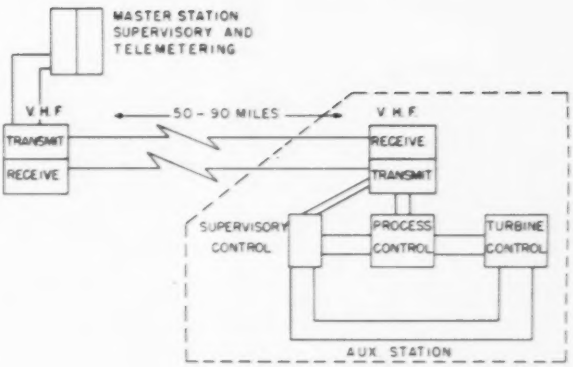


Fig. 8. Control signal routing schematic.

tion is carried over both channels. This is used to avoid interruption of contact between the master station and the operating station in case of failure of one of the channels. One channel is also available for voice communication.

DETAILS OF CONTROL PANELS

The front view of the master supervisory panel is shown in Fig. 9. The top instrument is the ambient temperature indicator. Located directly below is a chart recorder for the process functions. The lower section of the panel contains the supervisory control functions. The basic functions required for controlling the turbine are the start and stop selector keys, the raise and lower set point selector keys, and selector keys connected to the voice communication channel which will initiate contact so that a microphone in either the pump room or turbine room of the operating unit can be heard at the master station. Also located on the panel are three alarm groups indicating first, second, and third order alarm functions, in the order of importance. First order alarms normally are serious enough that the turbine unit is tripped and someone should go to the station before restarting the unit. Other order alarms may not cause tripping of the unit but if they do, it is permissible to restart the unit before someone goes to the station to investigate the difficulty.

One of the interesting features is the remote control of the automatic start-up and operation of the unit.

The operator at the master supervisory control first checks to see that the panel is clear of alarms and in remote start position. He then depresses the "start" selector key. This sends a signal to the turbine control panel which, in turn, sends a signal to the motor starter panel to start d-c motors (fans, pump, etc., required for starting). After a 5-minute interval required for purging the turbine cab with d-c purge fan, the starting diesel is started automatically, the clutch is engaged, and the turbine is accelerated to firing speed. After firing, the turbine is accelerated to operating speed. During accelerating, the a-c shaft driven generator breaker is closed, the a-c station motors are started in preset sequence, and the d-c motors are shut down. After that, a

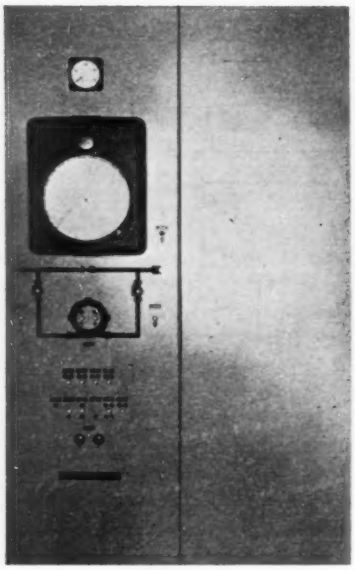


Fig. 9. Front view of the master supervisory control panel.

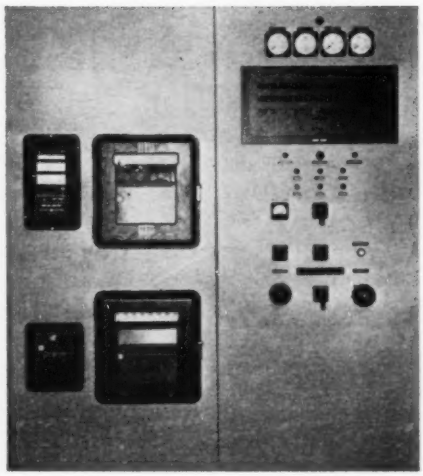


Fig. 10. Front view of the turbine control panel.

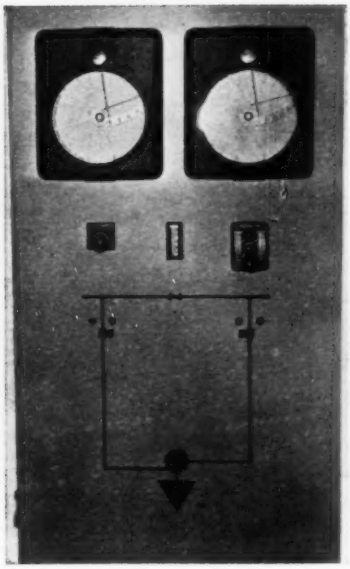


Fig. 11. Front view of the process control panel.

signal is sent back to the master control panel, indicating that the starting sequence has been completed. The entire sequence of operation is automatic after the operator depresses the start key.

The unit is now ready for adjustment of discharge pressure set point. This is controlled by the operator depressing the raise or lower set point selector keys as required. Once a set point has been established, the process control automatically maintains the turbine-pump set at the required speed to maintain this discharge pressure until a new setting is required.

A front view of the turbine control panel is shown in Fig. 10. This panel is of the duplex type of construction. The left-hand side of this panel contains a vibration recorder and two temperature recorders which maintain records of pertinent process and station temperatures. The right-hand section of the panel contains the turbine control equipment; at the top are speed indicators of the high-pressure and low-pressure turbine shaft, second-stage nozzle position indicator, and fired hours timer. Directly below these indicators is a 36-point annunciator panel. Directly below these are lighting groups indicating various unit information, as well as required selector switches for starting, stopping, and operating the turbine locally.

A front view of the process control panel is shown in Fig. 11. The process system basically compares a pneumatic pressure established by a transmitter (which converts a process pressure to a pneumatic pressure signal) to an established pressure which is a function of the desired process pressure (set point). If there is a difference in these readings, an "error" signal is sent to the turbine control to increase or decrease turbine speed as desired. In addition to the basic controls, there are overriding features which limit the rate of change of pressure and limit the minimum suction and maximum discharge pressure to prevent pump or pipeline damage. The equipment shown consists of two recorders, to keep records locally of various process functions as well as necessary instruments and controls for operating the process set point locally.

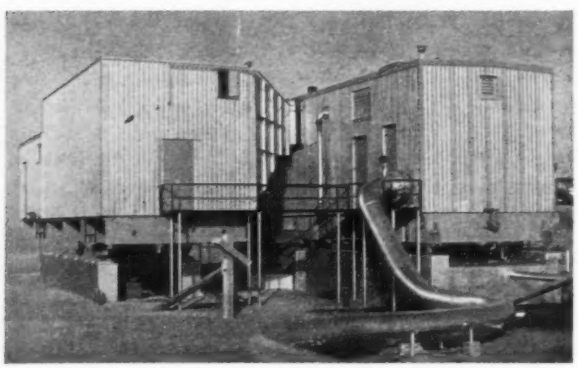


Fig. 12. Completed installation of turbine and control vans.

INSTALLATION AND OPERATION

THE TURBINE AND CONTROL VANS were hauled overland on giant low bed trailers preparatory to installation. The trailer used was 78 feet long, 26 feet wide, and had a load capacity of 150 tons. The rear trailer tires were 9½ feet in diameter. The completed installation of the turbine and control vans is shown in Fig. 12.

Operating experience is still in the preliminary stages but several thousand hours have now been logged and it appears that the auxiliary pumping units will meet the design specifications fully.

Temperature Rise of Solid Junctions

E. J. DIEBOLD
MEMBER AIEE

SEMICONDUCTOR DEVICES always contain a junction; i.e., a plane zone of vanishing thickness. Current pulses through the device generate heat, mostly in the zone, from which it diffuses into the adjoining metallic body. Heat causes an increase of temperature in the junction, depending on the size of the current pulse and the rate of heat dissipation. Measurements on alloy junction diodes lead to a curve of temperature rise against pulse duration which does not agree with any single theory of heat transfer. Investigating the problem reveals the need to consider a multitude of factors (materials, dimensions, shapes) which cannot be fitted to a single mathematical model. Satisfactory analysis, without undue complications, can be achieved in four successive steps, described in Table I. Considering each step, we assume that the preceding step is transferring heat at a steady rate (i.e., neglecting heat storage) and the following step is not yet subjected to a significant heat flow. Careful selection of boundaries and time limits leads to a valid approximation; or, inversely, an observed pulse-time characteristic can be interpreted by the theory to gain an insight into the modes of internal heat transfer.

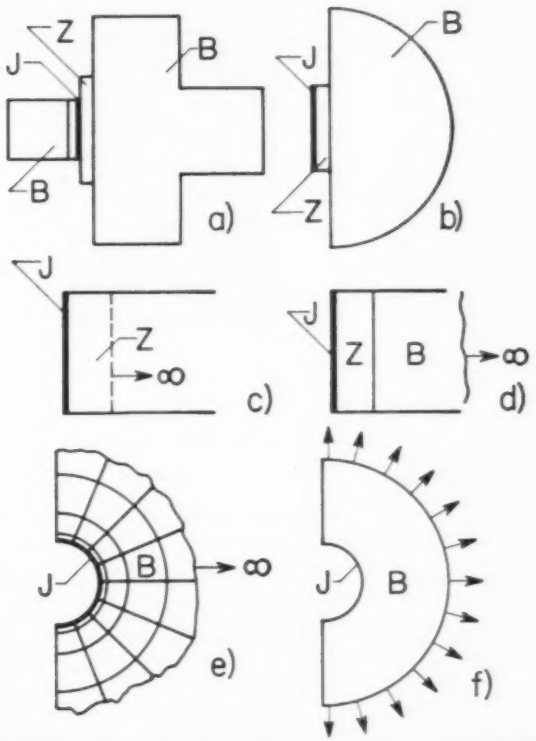


Fig. 1. (a) Junction device; (b) simplified for analysis; (c), (d), (e), (f) approximations according to the table; J—junction; Z—initial zone; B—body of device.

Table I.

Figure No.	Description of type of heat flow used as an approximation	Temperature—time function for pulse of constant magnitude
1c	Plane diffusion into homogeneous body.	$I = C_1\sqrt{t}$
1d	Plane diffusion into homogeneous body through heat barrier.	$I = C_2 + C_3\sqrt{t}$
1e	Hemispherical diffusion into homogeneous body.	$I = C_4\{1 - \varepsilon^{+t/C_5}[1 - \Phi(t/C_5)]\}$
1f	Uniform heating through heat barrier of a lumped mass with external dissipation.	$I = C_6 - C_7\varepsilon^{-t/C_8}$

I = temperature increase t = time Φ = error integral
C_1 to C_8 = constants, depending on material, shape and size.

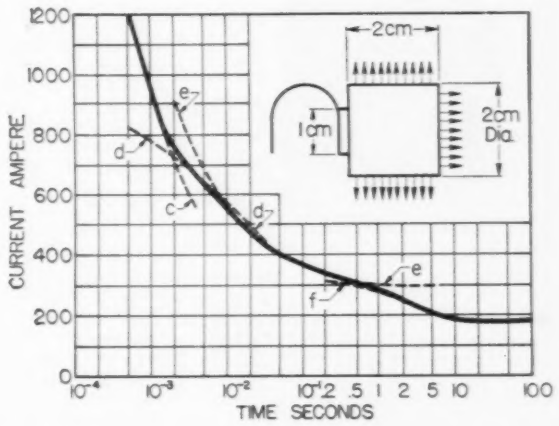


Fig. 2. Germanium rectifier with cathode cooling only. Pulse current-time curve for 40 C temperature rise.

Fig. 1 shows a schematic view of a device (*a*), its simplified form for analysis (*b*), and four steps of approximation (*c, d, e, f*) to which reference is also made in Table I and Fig. 2. A hypothetical junction device (concentrated mass and heat sink on the periphery) is shown in Fig. 2, together with a pulse-current-time curve calculated by this theory. Dotted lines indicate the curves for the approximations (*c, d, e, f*); the solid line follows an estimated curve for the device itself.

Digest of paper 57-144, recommended by the AIEE Basic Sciences Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Summer General Meeting, Montreal, Que., Canada, June 24-28, 1957. Scheduled for publication in AIEE *Communication and Electronics*, 1957.

E. J. Diebold is with the International Rectifier Corp., El Segundo, Calif.

INSTITUTE ACTIVITIES

Membership Campaign for Funds for New United Engineering Center Opens

PROMINENT ENGINEERING FIGURES have demonstrated their support of the campaign for funds for the new United Engineering Center, to be erected on United Nations Plaza between 47th and 48th Streets, New York City, by the following statements:

Hon. Herbert Hoover, honorary chairman, Industry Campaign:

"A drive by the United Engineering Societies for the funds to erect a new building has been launched. We need the support of all our members.

"We have a site. We urgently need to start our new building. It is of national importance.

"The activities of these societies are of vital importance to the American people and to the engineers."

Courtesy Harris & Ewing

Hon. Herbert Hoover

J. R. Killian, Jr., president, Massachusetts Institute of Technology:

"We are now witnessing, belatedly, a great national effort properly to recognize, to deploy, and to strengthen the resources of engineering and science in the United States. The United Engineering Center is an apt and timely move toward this goal.

"I enthusiastically endorse and support the campaign we have launched."

D. A. Quarles, Deputy Secretary of Defense:

"I am delighted to say that the venture now embarked upon . . . is a thing of utmost importance to the country, to its long-term security, to its long-term soundness, and to the ability of the country to meet this challenge and to prove that free enterprise and the American genius for doing things can take this problem on and can meet any competition that anybody in the world can give it."

R. J. Cordiner, president, General Electric Company:

"I say to you gentlemen that this kind of expenditure, if it's wise—which it is—is going to be reflected in better products, better results, a better standard of living.

"I think it's due but it's going to need the help and support and the enthusiastic endorsement of not only you gentlemen present but all your associates across the country.

"I know, speaking for the many, that we'll recognize our responsibility—you do your part of the job, we'll get ours done."

A. P. Sloan, Jr., honorary chairman, General Motors Corporation:

"In all our business affairs, we have all kinds of problems presented to us and almost every problem has its advantages and disadvantages and we have to weigh the two and get a proper balance. In this case, there doesn't seem to be anything against it; it seems to me that it's a 'must.'

"All I want to say is: let's get together, let's put our shoulders to the wheel, let's help Dr. Kelly and the men that have agreed to help him in getting this thing across—and let's do it quickly in a very big way."

W. J. Barrett, president of United Engineering Trustees, Inc., and president of AIEE:

"If the engineering societies are to serve the growing membership effectively, there is no doubt that more and better planned space is required—and urgently.

"This project is the largest and most important single project ever to be undertaken by the organized engineering profession. Recent events point up the extreme importance of the engineering societies to the nation. The new center will provide a splendid opportunity for integration and closer co-operation among the various societies for more effective service to the entire engineering profession."

Courtesy Pach Bros.

W. J. Barrett

M. J. Kelly, general Industry Campaign manager:

"This new facility is a must for the societies, industry, and the nation. It must be financed. The members of the societies and industry are the sources of the funds. I am confident that their response will provide the amount of money which is required."

J. R. Killian, Jr.

Official U.S. Air Force Photo

D. A. Quarles

Burns Photography

R. J. Cordiner

A. P. Sloan, Jr.

M. J. Kelly

C. F. Kettering

C. F. Kettering, honorary chairman, United Engineering Center Building Fund, Member-Gifts Campaign:

"Today, the significance of engineering is being recognized as never before.

"The engineer, therefore, needs an adequate platform from which to expound his efforts as a creator of economic and social values. He needs a symbol of his dynamic purpose.

"The new United Engineering Center, a focus of life for 16 national engineering societies, will provide the platform and the symbol.

"Every engineer has a responsibility to participate in attaining this great objective by making a personal contribution to the United Engineering Center Fund Campaign.

"The program is sound. It is timely. It merits your support.

"To you—my fellow engineers—I extend my strong personal endorsement of the project. I urge you to give, not only in dollars but in service to the campaign."

Member-Gifts Campaign Leaders

The Member-Gifts Campaign has enlisted the following leadership:

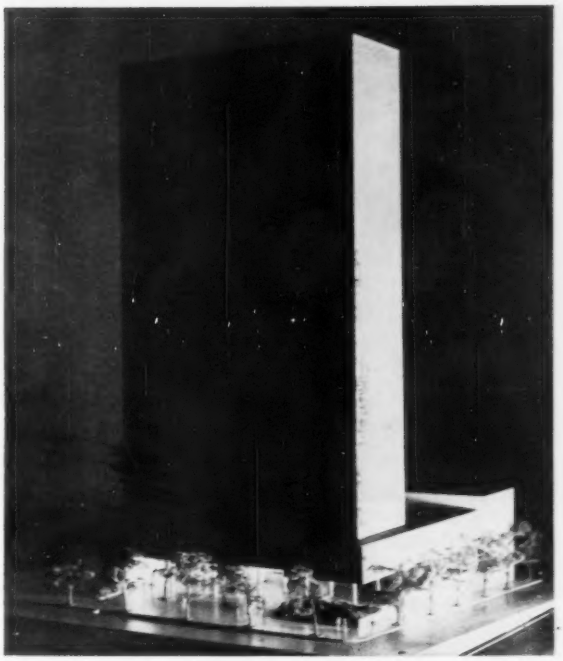
Honorary Chairman—C. F. Kettering
Honorary Vice-Chairmen—L. R. Howson, American Society of Civil Engineers (ASCE); G. J. Holt, American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME); J. N. Landis, The American Society of Mechanical Engineers (ASME); W. J. Barrett, AIEE; G. E. Holbrook, American Institute of Chemical Engineers (AIChE)
General Campaign Chairman—R. E. Dougherty
Cochairmen—Enoch Needles, ASCE; A. B. Kinzel, AIME; W. F. Ryan, ASME; Lester Goldsmith, AIEE; Walter Whitman, AIChE; S. R. Kirkpatrick, AIChE
Treasurer—C. B. Molineaux
Public Relations—W. E. Jessup
Executive Director—C. E. Davies

Help Build the New United Engineering Center

Members may contribute immediately to the building fund. Here is the answer to the question of tax refunds:

"Contributions made to you are deductible by the donors in computing their taxable net income in the manner and to the extent provided by section 170 (b) (1) and (2) of the 1954 code."—Letter from U. S. Treasury Department, Internal Revenue Service, to United Engineering Trustees, Inc., dated August 14, 1957.

Checks should be made out to United Engineering Trustees, Inc., and mailed to them at 29 West 39th Street, New York 18, N. Y.



MODEL (*right*) of the new $10 million United Engineering Center which will be erected on United Nations Plaza between 47th and 48th Streets in New York City. When completed, the new building will serve as the headquarters of 16 National Engineering Societies.

Associated Societies

In addition to the five Founder Societies, 11 associated Societies are planning to obtain housing in the new Center. They include: American Institute of Industrial Engineers, Inc.; American Rocket Society, Inc.; American Institute of Consulting Engineers; American Society of Refrigerating Engineers; American Water Works Association; Society of Naval Architects and Marine Engineers; Illuminating Engineering Society; American Society of Heating and Air-Conditioning Engineers, Inc.; The Electrochemical Society, Inc.; American Welding Society; Society of Motion Picture and Television Engineers.

Related Activities

Related activities to be housed in the new Center also include: Engineering Foundation; Welding Research Council; Engineering Index Inc.; Engineers' Council for Professional Development; American Standards Association.

New York Electrical Engineers Donate $15,000 for New United Engineering Center

A CHECK FOR $15,000 was presented Thursday evening, December 5, to the United Engineering Trustees, Inc. (UET) for the projected United Engineering Center by the New York Section of AIEE, in ceremonies in the Western Union Company Auditorium, New York, N. Y. The presentation was made to W. J. Barrett, president of UET, and president of AIEE, by R. W. Gillette, chairman of the New York Section, AIEE, on behalf of the Section's Divisions.

In presenting the check, Mr. Gillette pointed out that the New York Section's contribution is the first major gift by AIEE's 112 Sections and expressed hope that the New York action would stimulate other Sections of AIEE and similar societies to make contributions to the Building Fund.

The New York Section check will be added to funds now being raised for the $10 million building which will be erected on United Nations Plaza between 47th and 48th streets, New York, and will replace the half-century old building at 33 West 39 St., which houses four of the Founder Societies—AIEE; the American

Courtesy Ross Photos

W. J. BARRETT (*front, left*), president of AIEE and president of United Engineering Trustees, Inc., accepts a $15,000 check for the projected United Engineering Center from R. W. Gillette (*front, right*), chairman of the New York Section of AIEE. Observing the presentation are: (*back row, left to right*) S. H. Grim, C. E. Rider, C. I. Hubert, A. W. Segil, W. O. Arnold, and G. H. Needham.

Institute of Mining, Metallurgical and Petroleum Engineers; the American Institute of Civil Engineers; and The American Society of Mechanical Engineers, as well as other engineering societies. These, together with the fifth founder society, the American Institute of Chemical Engineers, and other engineering societies, will occupy the new building.

Mr. Barrett described the new building, showed a model of it, and told of the project's progress.

Prior to the check presentation ceremony, nine members of the New York Section recently elevated to the grade of Fellow were introduced and certificates were presented to past Section and National officers for services rendered during the past year.

New Fellows recognized were: E. H. Anson, senior vice-president, Gibbs and Hill; J. G. Ferguson, transmission measurement engineer, Bell Telephone Laboratories; A. R. Gruehr, head, history economics department, Polytechnic Institute of Brooklyn; C. H. Linder, vice-president, engineering services, General Electric Company; A. V. Loughren, vice-president, Airborn Instrument Laboratory, Inc.; L. J. Lunas, engineering manager, instrument department, Westinghouse Electric Corporation; A. J. Petzinger, manager, instrument department, Westinghouse Electric Corporation; H. I. Romnes, vice-president, operating and engineering department, American Telephone and Telegraph Co.; and H. L. Rorden, research and high-voltage practice engineer, American Gas and Electric Service Corp.

A demonstration lecture on "New Adventures in Electronics," by C. N. Hoyler, RCA Laboratories, followed. Mr. Hoyler described recent advances in the fields of solid-state physics, television and acoustics, including the amplification of light, the production of refrigeration, and a new type of electronic speed photography, and demonstrated a pocket size television camera for industrial use, and a music synthesizer.

The meeting, which was the first general gathering of the Section this season, was sponsored by the Section Communication Division. Mr. Gillette and W. O. Arnold, chairman of the Communication Division, presided.

Courtesy Ross Photos

NEW YORK SECTION CHAIRMAN R. W. Gillette (*far left*) congratulates Section members recently transferred to the grade of Fellow: (*left to right*) H. L. Rorden, J. G. Ferguson, L. J. Lunas, A. V. Loughran, and A. R. Gruehr, at a New York Section Meeting held Thursday evening, December 5, 1957.

Leading Figures Sponsor National Engineers' Week

Some 14 leading engineering figures will act as sponsors for the 1958 National Engineers' Week, February 16-22.

The list of sponsors was announced by J. L. Bahr, national chairman of the observance held annually during Washington's birthday week under the general sponsorship of the National Society of Professional Engineers.

The 14 individual sponsors are: J. R. Killian, Jr., president, Massachusetts Institute of Technology, and newly appointed special assistant to President Eisenhower for science and technology; A. B. DuMont, chairman of the board, Allen B. DuMont Laboratories, Inc.; Major General E. C. Itschner, chief of engineers, United States Army; C. F. Kettering, General Motors Corporation; C. H. Linder, vice-president, General Electric Company; T. E. Murray, consultant, Joint Committee on Atomic Energy; G. M. Read, chief engineer, E. I. du Pont de Nemours & Co. (Inc.); Rear Admiral H. G. Rickover, chief of naval reactors, United States Atomic Energy Commission; R. W. Sorensen, California Institute of Technology; Philip Sporn, president, American Gas and Electric Company; D. B. Steinman, consulting engineer; B. D. Tallamy, Federal Highway Administrator; C. A. Thomas, president, Monsanto Chemical Company; and R. E. Wilson, chairman of the board, Standard Oil Company of Indiana.

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

AIEE Future Meetings

Winter General Meeting*
Hotel Statler
New York, N. Y.
February 2-7, 1958

AIEE-IRE-U of P Transistor and Solid State Circuits Conference*
Philadelphia, Pa.
February 20-21, 1958

Textile Conference*
Georgia Institute of Technology
Atlanta, Ga.
March 13-14, 1958

EJC Nuclear Congress*
International Amphitheatre
Chicago, Ill.
March 17-21, 1958

AIEE-ASME Engineering Management Conference*
Boston, Mass.
March 19-20, 1958

American Power Conference*
Sherman Hotel
Chicago, Ill
March 26-28, 1958

Pulp and Paper Conference*
North Carolina State College
Raleigh, N. C.
March 27-29, 1958

South West District Meeting*
Mayo Hotel
Tulsa, Okla.
March 31-April 2, 1958

AIEE-ASME-IRE-ISA-AIChE Automatic Optimization Conference*
University of Delaware
Newark, Del.
April 2-4, 1958

AIEE-ASME Railroad Conference
Cleveland, Ohio
April 9-10, 1958
(Final date for †TP—closed, ‡CP Syn.—closed, CPMs—Feb. 3)

Rubber and Plastics Conference
Mayflower Hotel
Akron, Ohio
April 14-15, 1958
(Final date for †TP—closed, ‡CP Syn.—closed, CPMs—Feb. 7)

AIEE-IRE-ASME Automatic Techniques Conference (Automation and Data Processing)
Statler Hotel
Detroit, Mich.
April 14-16, 1958
(Final date for †TP—closed, ‡CP Syn.—Feb. 25, CPMs—Feb. 7)

AIEE-IRE-EIA-WCEMA Joint Electronic Components Conference
Ambassador Hotel
Los Angeles, Calif.
April 22-24, 1958
(Final date for †TP—closed, ‡CP Syn.—Feb. 5, CPMs—Feb. 15)

Middle Eastern District Meeting
Washington, D.C.
April 28-30, 1958
(Final date for †TP—closed, DPMs —Feb. 11)

Great Lakes District Meeting
Michigan State University
East Lansing, Mich.
May 5-7, 1958
(Final date for †TP—closed, DPMs —Feb. 11)

AIEE-IRE-ACM Western Joint Computer Conference (Exhibit)
Ambassador Hotel
Los Angeles, Calif.
May 6-9, 1958
(Final date for †TP—closed, ‡CP Syn.—Feb. 18, CPMs—Feb. 28)

East Central District Meeting
Huntington, W. Va.
May 13-15, 1958
(Final date for †TP—closed, DPMs —March 11)

Materials Handling Conference
Pittsburgh, Pa.
May 19-20, 1958
(Final date for †TP—Feb. 7, ‡CP Syn.—March 4, CPMs—March 14)

Appliance Technical Conference
Hotel Morrison
Chicago, Ill.
May 26-27, 1958
(Final date for †TP—Feb. 14, ‡CP Syn.—March 11, CPMs—March 21)

AIEE-ISA-IAS-ARS National Telemetering Conference (Exhibit)
Lord Baltimore Hotel
Baltimore, Md.
June 2-4, 1958
(Final date for †TP—Feb. 21, ‡CP Syn.—March 18, CPMs—March 28)

Summer General Meeting
Buffalo, N. Y.
June 22-27, 1958
(Final date for †TP—March 14, ‡CP Syn.—April 3, CPMs—April 7)

AIEE-IRE Nonlinear Magnetics and Magnetic Amplifiers Conference (Exhibit)
Los Angeles, Calif.
August 5-8, 1958
(Final date for †TP—April 25, ‡CP Syn.—May 20, CPMs—May 30)

Pacific General Meeting
Sacramento, Calif.
August 19-22, 1958
(Final date for †TP—May 9, ‡CP Syn.—June 3, CPMs—June 6)

Petroleum Industry Conference
Baker Hotel
Dallas, Texas
September 15-17, 1958
(Final date for †TP—June 6, ‡CP Syn.—July 1, CPMs—July 11)

AIEE-IRE-ASME National Power Conference
Boston, Mass.
September 28-October 1, 1958
(Final date for †TP—June 20, ‡CP Syn.—July 15, CPMs—July 25)

AIEE-IRE-EIA-SMPTE National Electronics Conference
Chicago, Ill.
October 13-15, 1958
(Final date for †TP—July 4, ‡CP Syn.—July 29, CPMs—Aug. 8)

Machine Tools Conference
Statler Hotel
Hartford, Conn.
October 13-15, 1958
(Final date for †TP—July 4, ‡CP Syn.—July 29, CPMs—Aug. 8)

Fall General Meeting
Pittsburgh, Pa.
October 26-31, 1958
(Final date for †TP—June 27, ‡CP Syn.—Aug. 4, CPMs—Aug. 8)

AIEE-IRE-ACM Eastern Joint Computer Conference (Exhibit)
Bellevue-Stratford Hotel
Philadelphia, Pa.
December 3-5, 1958
(Final date for †TP—Aug. 25, ‡CP Syn.—Sept. 19, CPMs—Sept. 29)

AIEE-IRE-ASQC-EIA National Symposium on Reliability and Quality Control
Bellevue-Stratford Hotel
Philadelphia, Pa.
January 12-14, 1959
(Final date for †TP—Oct. 3, ‡CP Syn.—Oct. 27, CPMs—Nov. 7)

Winter General Meeting
New York, N. Y.
February 1-6, 1959
(Final date for †TP—Oct. 14, ‡CP Syn.—Nov. 5, CPMs—Nov. 7)

Southern District Meeting
Atlanta, Ga.
April 8-10, 1959
(Final date for †TP—Dec. 27, CPMs —Jan. 12)

*Final date for submitting papers—closed
†TP—Transactions Paper
‡CP Syn.—Conference Synopsis
CPMs—Conference Manuscript
DPMs—District Manuscript
(District Paper Synopses should be directed to the District Meeting Committee)

Westinghouse Photo

SCULPTOR EDMONDO QUATTROCCHI works on a bust of George Westinghouse for the NYU Hall of Fame for Great Americans. The bust was unveiled by AIEE President Barrett during ceremonies held on Sunday afternoon, December 1, 1957.

AIEE President Barrett Unveils Bust of Westinghouse for Hall of Fame

SUNDAY AFTERNOON, December 1, 1957, W. J. Barrett, president of AIEE, unveiled a bronze bust of George Westinghouse for the Hall of Fame for Great Americans at New York University (NYU). A bust of Josiah Willard Gibbs also was unveiled at the ceremony, witnessed by more than 1,000 persons, which took place in the Gould Memorial Library Auditorium on the University Heights campus of NYU.

Principal speakers at the event were former President Herbert Hoover and Dr. D. W. Bronk, president of the National Academy of Sciences. Dr. R. W. Sockman, director of the Hall of Fame and minister of Christ Church Methodist, presided. Dr. C. V. Newsom, president of NYU, accepted the bronzes for the Hall of Fame.

Westinghouse Photo

BRONZE BUST of George Westinghouse for the NYU Hall of Fame for Great Americans is unveiled by AIEE President W. J. Barrett (*center*). Participating in the ceremonies are Dr. R. W. Sockman (*left*), director of the Hall of Fame, and three descendants of Westinghouse: Mrs. Agnes Simpson (*second from left*), granddaughter; Aubrey Westinghouse (*second from right*), grandson; and Mrs. Margaret Kunater, (*right*), granddaughter.

Westinghouse, inventor of the air brake and many electrical devices, was chosen for enshrinement in the Hall of Fame in 1955. His likeness, a gift of the American Society of Mechanical Engineers (ASME), is the work of sculptor Edmondo Quattrocchi.

Gibbs, a mathematical physicist and professor at Yale University, formulated the theory of thermodynamics, the basis for much of modern physical chemistry and chemical engineering. He was selected for the posthumous honor in 1950. The Gibbs bust is the gift of the American Chemical Society, Yale, and several individual donors. The sculptor was Stanley Martineau.

The Westinghouse bronze was presented to the Hall of Fame by Dr. W. F. Ryan, president of the ASME, and unveiled by AIEE President W. J. Barrett.

Dr. J. G. Kirkwood, Sterling Professor of Chemistry and director of sciences at Yale, presented the Gibbs bust, which was unveiled by a nephew of the 19th Century scientist, Dr. R. G. VanName, research associate emeritus in chemistry at Yale.

Bronze plaques bearing quotations from Westinghouse and Gibbs were placed in the shrine beneath their busts.

The Westinghouse tablet reads: "If someday they say of me that in my work I have contributed something to the welfare and happiness of my fellow men, I shall be satisfied."

Inscribed on the Gibbs plaque: "One of the principal objects of theoretical research is to find the point of view from which the subject appears in its greatest simplicity."

The Reverend Dr. Sidney Lovett, chaplain of Yale, gave the invocation, and Dr. A. J. Brown, the oldest member of the Hall of Fame's College of Electors, delivered the benediction. Dr. Brown, a retired minister, is now in his 101st year.

Members of the Yale Glee Club under the direction of Fenno Heath provided musical interludes during the program. Associate professor H. J. Heeremans of NYU served as organist for the ceremonies.

Gibbs, who lived from 1839 to 1903, and Westinghouse, who lived from 1846 to 1914, are the 84th and 85th distinguished persons to be enshrined in the Hall of Fame. A bronze of Wilbur Wright, co-inventor of the first man-carrying airplane who was elected in 1955, will be added in the near future.

The next Hall of Fame election will take place in 1960. Nominations from the public will be accepted after April 1, 1959. To qualify, a candidate must have been dead at least 25 years and must have been an American citizen.

Final selections are made by a College of Electors composed of 125 distinguished persons from all walks of life and from each of the 48 states.

The Hall of Fame was founded in 1900 by Dr. Henry Mitchell MacCracken, then chancellor of NYU. Its colonnade is one of the last examples of the architecture of Stanford White.

Bimonthly Publications

The bimonthly publications, *Communication and Electronics*, *Applications and Industry*, and *Power Apparatus and Systems*, contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

Jules Schick, Photography

DURING THE AIEE Philadelphia Section Career Forum, B. S. Roberts (left) plays a tune on the miniature transistor organ while A. L. Charny looks on.

President Eisenhower Praises AIEE Career Forum

PRESIDENT EISENHOWER in a telegram to Robert Neathery, director of museum education at Philadelphia's world-famous Franklin Institute and moderator of the AIEE Engineering Career Forum held at the Franklin Institute November 12-14, 1957, praised efforts to advance the study of science in our high schools.

The President, in his message which was read to the almost 900 junior and senior high school students representing over 75 schools in Southeastern Pennsylvania and Southern New Jersey, said:

"Please give my greetings to the young people of Philadelphia attending the Engineering Career Forum sponsored by the Franklin Institute and the American Institute of Electrical Engineers.

"It is encouraging to learn of this fine effort to advance study of science in our high schools for the continuing progress and protection of our land. It is essential to broaden the base of our trained scientific personnel.

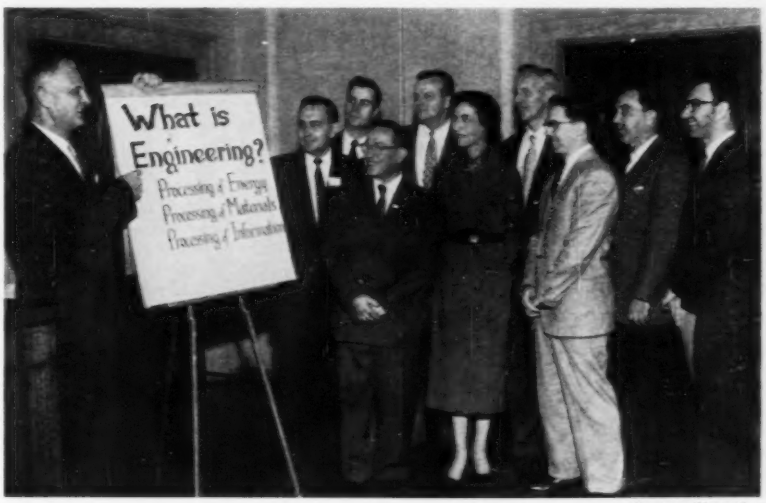
"Best wishes for a splendid Forum."

The program presented was the result of intensive planning by the Philadelphia Section AIEE Secondary Schools Committee and the Franklin Institute in cooperation with the area's industrial and education leaders. The Forum included a demonstration of the solar battery and other recent developments of the Bell Telephone Company by B. S. Roberts and A. L. Charny and three short talks: "An Engineering Career" by C. T. Pearce, Atlantic Region engineering and service manager, Westinghouse Electric Corporation; "A Young Engineer in Industry" by D. L. McDonald, Electrical Engineering Division, Philadelphia Electric Company; "Electrical Engineering Education" by Dr. H. E. Tompkins, Moore School, University of Pennsylvania.

Upon completion of the formal portion of the program, the students received guidance counselling from over 25 college and industry representatives. The counsellors represented all fields of engineering and science. In addition, envelopes containing descriptive material on engineering and science careers were passed out to all of the students attending the Forum.

A preview of the Forum program was presented before a group of over 300 area industrial and educational representatives late in October. Many of their excellent suggestions were incorporated into the final program.

Chairman of the Forum Committee is E. M. Callender, The Budd Co., and the vice-chairman, H. W. Sommer, Jr., Bell Telephone Company of Pennsylvania. Other committee members are: C. Mansky, Burroughs Corp.; O. A. Huntsman, General Electric Company; R. Schwartz, University of Pennsylvania; H. E. Tompkins, University of Pennsylvania; A. J. Williams, Leeds and Northrup Co.; and G. W. Gordon, Philadelphia Electric Co. Representing the Franklin Institute were Robert Neathery, director of museum



Courtesy Photo-Arts

SOME PARTICIPANTS in the AIEE Philadelphia Section Career Forum are: (left to right) C. T. Pearce, Forum speaker; H. W. Sommer, Jr.; B. S. Roberts, Forum speaker; A. L. Charny, Forum speaker; E. M. Callender, Forum Committee chairman; Mrs. J. Watt, Franklin Institute; Dr. J. S. Burlew, executive vice-president of Franklin Institute; D. L. McDonald, Forum speaker; R. Neathery, Forum moderator; and G. W. Gordon.

education and his assistant, Mrs. J. Watt.

Co-operating companies were: Burroughs Corporation, General Electric Company, I-T-E Circuit Breaker Company, Leeds and Northrup Co., Philadelphia Electric Co., Philco Corporation, Pringle Electrical Manufacturing Co., Radio Corporation of America, The Bell Telephone Company of Pennsylvania, The Budd Company, United Engineers and Constructors, Inc., and Westinghouse Electric Corporation.

Progress in Nuclear Energy Uses To Be Demonstrated at Nuclear Congress

THE ATOMIC ENERGY INDUSTRY of the United States will demonstrate its progress in the uses of nuclear energy for the benefit of the western world during the 1958 Nuclear Congress, March 17-21, 1958, at the International Amphitheater, Chicago, Ill.

Additional declassification of information will make it possible for the 1958 Nuclear Congress to make available material to give further meaning to the conclave's slogan, "Industrializing the Atom."

More than 30 sponsoring organizations will bring together leaders in science, engineering, industry, Government, education, health, and agriculture in this biggest nuclear assembly, which will include the Fourth Nuclear Engineering and Science Conference; the atomic exposition, "AtomFair"; the 6th Hot Laboratories and Equipment Conference; the Atomic Energy Management Conference; and the American Power Conference.

Co-ordinating agency for the Nuclear Congress is Engineers Joint Council, while the management is under the direction of the American Insitute of Chemical Engineers (AIChE).

B. R. Prentis, of the General Electric Company, is general chairman of the 1958 Nuclear Congress and J. W. Landis of Babcock and Wilcox Company and the American Nuclear Society is program chairman of the Nuclear Engineering and Science Conference. Dr. J. R. Dunning, dean of engineering, Columbia University, is chairman of the Nuclear Congress Policy Board. The 1958 Nuclear Congress manager is Joel Henry of the AIChE.

The four major elements of the 1958 Congress and the area each covers are:

1. The Nuclear Engineering and Science Conference on behalf of more than 30 participating engineering and scientific societies, will present 150 technical papers on late developments in the several fields of atomic energy applications, including a number of papers on aircraft propulsion.

2. The Atomic Industrial Forum, Inc., AtomFair will be held in conjunction with the technical sessions of the Congress and will feature the latest developments in industrial uses of atomic energy. Registration for the AtomFair is open to Congress delegates and to science-minded people in industry.

3. Atomic Energy Management Conference, sponsored jointly by the National Industrial Conference Board and the Atomic Industrial Forum, Inc., which will provide management with a comprehensive review of progress made to develop low-cost nuclear power and other industrial uses of atomic energy. Representatives from industry, science, and management from many countries will discuss the impact of the atom on our economy.

4. The Sixth Hot Laboratories and Equipment Conference, sponsored by the Hot Laboratories Committee of the Oak Ridge National Laboratories, will deal with the highly technical details of the development of equipment and the operation of laboratories for atomic energy.

The American Power Conference also is participating in the Congress. Thus, the representatives from many countries to this meeting will be enabled to participate in the aspects of power generation covered by the Nuclear Congress.

Attendance at the 1958 Nuclear Congress is expected to exceed that of the 1957 Congress in Philadelphia, Pa., when 16,000 participated, including 3,000 at the technical meetings.

The AtomFair and the conferences are to be held at the International Amphitheater, while headquarters hotel will be the Palmer House.

J. W. Landis, chairman of the Nuclear Engineering and Science Conference Program Committee, has announced the following general categories which will be covered in the technical meetings: Commercial Use of Radioactive Tracers; Reactor Component Development, Fabrication, and Testing; Standardization, Codes, and Licensing; Reactors for Process Heat and Radiation; Production and Miscellaneous Applications of Radioisotopes; Reactor Operation and Maintenance; Fuel, Control, Moderator, and Coolant Materials; Experimental Power Reactors and Advanced Concepts; Health Physics and Instrumentation; Reactor Physics; Temperature Measurement and High Temperature Instrumentation; Waste Treatment and Disposal; Reactor Plant Instrumentation; Reactor Location and Safety; Thermal and Mechanical Design; Reactor Control Instrumentation; Progress in Commercial Power Reactor Development; Reactor Plant Materials; Fuel Element Development, Fabrication, and Testing; Reactor Safety and Start up Instrumentation; Reactor Systems Analysis; Research and Test Reactors and Critical Assemblies; Chemical Reprocessing; Water Contamination and Treatment and Reactor Shielding and Containment.

Sponsoring groups for the 1958 Nuclear Congress include: AIEE; American Chemical Society; The American Institute of Architects; American Institute of Chemical Engineers; American Institute of Consulting Engineers; American Institute of Industrial Engineers, Inc.; American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc.; The American Nuclear Society; American Power Conference; The American Public Health Association; American Rocket Society, Inc.; American Society of Agricultural Engineers; American Society of Civil Engineers; American Society for Engineering Education; American Society of Heating and Air-Conditioning Engineers; The American Society of Mechanical Engineers; American Society for Metals; American Society for Testing Materials; American Water Works Association; The Engineering Institute of Canada; Federation of Sewage and Industrial Wastes Association; The Health Physics Society; Institute of Aeronautical Science, Inc.; The Institute of Radio Engineers, Inc.; Instrument Society of America; The Society of American Military Engineers; Society of Automotive Engineers, Inc. and the Society of Naval Architects and Marine Engineers.

The Western Society of Engineers, a member of Engineers Joint Council, will be the "host society" for the 1958 Nuclear Congress.

Chairman of the Chicago General Arrangements Committee is R. D. Maxson, Commonwealth Edison Company. The Chicago Committee has arranged trips to industrial plants in the Chicago area and to the Argonne National Laboratory especially for delegates to this Congress. There will be a student day program, presided over by Joyce Myron, the young lady who won $64,000 on the television program for her knowledge of atomic energy. The local Committee has also made provision for special activities for ladies attending.

G. C. Neuschaefer Receives National Reliability Award

G. C. Neuschaefer (AM '33) of the United States Naval Material Laboratories, Brooklyn, N. Y., was presented the first annual National Reliability Award at a banquet held at the Fourth National Symposium on Reliability and Quality Control in Electronics at the Statler Hotel, Washington, D. C., January 7, 1958, sponsored by AIEE, Institute of Radio Engineers, Electronic Industries Association, and American Society for Quality Control.

M. M. Tall, of the Radio Corporation of America, Symposium general chairman, presented Mr. Neuschaefer with the award, given for the outstanding technical paper presented at the 1957 symposium.

Mr. Neuschaefer is branch head of electronics at the United States Naval Shipyards in Brooklyn. He graduated from the Cooper Union Institute of Technology with a B.S. degree in E.E. in 1932.

Mr. Neuschaefer's paper, "Standard Parts—They Can Be Versatile," reviewed some of the pertinent history and current effort on reliability leading up to a proposal for the issuing of a "General Specification for Electronic Parts" which could provide the means of obtaining versatile

standard parts and components. In his paper, Mr. Neuschaefer concludes that such a specification should provide a ready means of reference to define objectives for new parts development; should specify operating conditions in a uniform manner and should provide a means of approving standard parts for peculiar applications. Mr. Neuschaefer also states that a general specification would minimize the number of approved parts without restricting application of available parts within their capabilities.

The National Reliability Award given for the first time this year, will continue to be a highlight of National Reliability Symposiums. Ballots were distributed to all attendees of the 1958 symposium to enable the attendees to select the best paper for the 1959 Award. This 1959 Award will be made at the Fifth National Symposium on Reliability and Quality Control which will be held at the Bellvue-Stratford Hotel, Philadelphia, Pennsylvania, January 12-14, 1959.

Conference Held on Computers in Control Systems

A Special Technical Conference on Computers in Control Systems was sponsored by the AIEE Feedback Control Systems Committee with participation by the Professional Group on Automatic Control of the Institute of Radio Engineers and the Instruments and Regulators Division (IRD) of The American Society of Mechanical Engineers (ASME). The meeting was held on October 16-18, 1957, in Atlantic City, N. J.

Conference Chairman John Truxal of the Polytechnic Institute of Brooklyn put together an excellent program of technical papers that attracted 376 of the country's top control engineers. The meeting assumed an international air by the attendance of Soviet, French, and English control engineers who contributed papers to the meeting. The USSR scientists were the prime center of attraction at the social hour with many clustering around to talk to them (all claimed to have taken no part in Sputnik).

The technical papers were excellent and were well received by the audience, leading to a feeling that these special conferences of the AIEE Feedback Control Systems Committee should be held more often than every three years. The technical sessions consisted of: 1. Broad aspects of computers in control; 2. Design of computers in control; 3. Computers in sampled data systems; 4. Analog and digital computers in control systems; and 5. Optimum systems through the use of computers.

A social hour and banquet were held with Adam Kegel of Westinghouse Electric Corporation acting as master of ceremonies. James Knowles, staff economist, Joint Economic Committee, Congress of the United States, delivered a thought-provoking address on "Our National Economy as a Control System." His conclusion was that if the barrier of nomenclature and association were removed, the control systems engineer would readily recognize our national economy as just another complex control system. This control system has an inherent low sampling rate and large time delays.

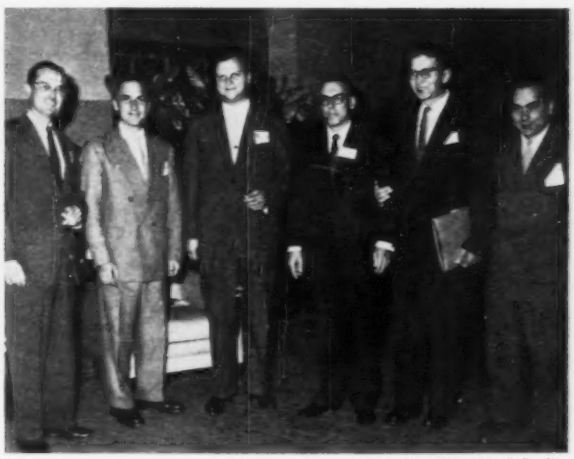
The highlight of the conference was a panel discussion on "Fitting Computers into Control Systems." The general conclusion was that computers have found a definite place in military control systems but obstacles lie ahead for use in industrial automation. Specifically, economic justification, reliability, and lack of process know-how were the three major hurdles referred to by both panel and audience. In the open discussion after the panel-member presentations, led by moderator Harold Chestnut of General Electric, there was evident a sincere desire by representatives of all branches of industry and the military to find out how to proceed in overcoming these obstacles.

ESL Notes Increase in Demand for Russian Material

Since the advent of Sputnik, the Translation Department of the Engineering Societies Library (ESL) has noted a substantial increase in inquiries from engineers and firms in the United States interested in translations of Russian technical publications. Today, more and more translations of Soviet Union technical and scientific material are becoming available, particularly some of the more recent publications. The ESL directs inquiries to the appropriate man or organization from whom existing translations are obtainable. When no existing translation of a particular technical item is known, the ESL will, on order, translate it correctly into good English. Translations are made from Russian or any other foreign language.

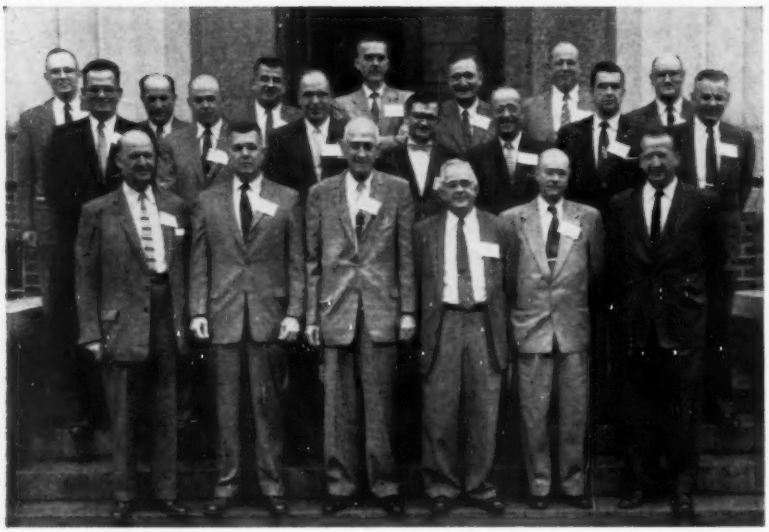
Also, there is an increasing demand for more up-to-date abstracting and indexing of original Soviet technical and engineering information not necessarily translated from the Russian as yet. The Engineering Index Service, which indexes the engineering publications received at the ESL, is expanding its coverage of Russian publications. In contrast to the period immediately following World War II, the Soviets are making their technical publications much more readily available. They have expressed great interest to the ESL in enlarging existing exchange arrangements, whereby the ESL sends them the publications of its four Founder Societies for equivalent Soviet Union material. This exchange is of great benefit to the United States, and will be further developed.

Courtesy Central Studios



Courtesy Central Studios

ENTERING THE FIRST SESSION *(above, left)* **of the Conference on Computers in Control Systems are** *(left to right)* **Prof. A. Susskind, Massachusetts Institute of Technology; Dr. Alexander Letov, Institute of Automatics and Telemechanics, Moscow, USSR; and Harold Chestnut, General Electric Company. Above, right: The international atmosphere at the conference is demonstrated by several of those attending,** *(left to right)* **W. E. Vannah, editor of Control Engineering; Marc Pelegrin, ministere de la Defense Nationale et des Forces Armees, Paris, France; Boris Naumov, Institute of Automatics and Telemechanics, Moscow, USSR; Rufus Oldenburger, Purdue University, chairman of the IRD of ASME; Dr. Letov; I. S. Mukhin, Institute of Precise Mechanics and Computing Technique, Moscow, USSR.**



MEMBERS of the Textile Industry Subcommittee present at AIEE Textile Conference at North Carolina State College, November 14-15, 1957, are: (*front row, left to right*) R. S. Gardner, AIEE Headquarters, New York, N.Y.; I. S. Bull, Roberts Co., Sanford, N.C., Subcommittee secretary; R. B. Flowers, General Electric Company, Atlanta, Ga., Subcommittee chairman; R. H. Clark, Warner & Swasey Co., Cleveland, Ohio, Subcommittee vice-chairman; Swaffield Cowan, Factory Insurance Association, Charlotte, N.C.; H. E. Strock, E. H. Gilliam Company, Charlotte, N.C., Conference co-chairman; (*second row, left to right*) Victor Sepavich, Crompton and Knowles Corp., Worcester, Mass.; R. B. Wood, Albany Felt Company, Albany, N.Y.; M. R. Brice, Cutler-Hammer, Inc., Milwaukee, Wis.; C. R. Moore, American Viscose Corp., Philadelphia, Pa.; J. T. Meador, Southern Electric Service Company, Charlotte, N.C.; G. C. Gaskin, J. E. Sirrine Company, Greenville, S.C.; J. M. Field, Burlington Industries, Greensboro, N.C.; (*back row, left to right*) A. T. Bacheler, Westinghouse Electric Corporation, Buffalo, N.Y.; John Bina, Dominion Textile, Montreal, Que., Canada; Barney Stratton, Cutler-Hammer, Inc., Atlanta, Ga.; R. R. Prochter, General Electric Company, Atlanta, Ga.; C. E. Robinson, Reliance Electric and Engineering Company, Cleveland, Ohio; Dan McConnell, Southern Electrical Equipment Company, Charlotte, N.C.; and L. C. Moore, Westinghouse Electric Corporation, Atlanta, Ga.

Last Call for Subscriptions to Volume 76 of 1957 AIEE Transactions

VOLUME 76 of the 1957 AIEE *Transactions*, bound in cloth with gold embossed lettering will be made available during March and April in three parts as follows: Part I. Communication and Electronics, Part II. Applications and Industry, Part III. Power Apparatus and Systems.

Each of these parts contains the papers officially approved by the technical committees collated with the discussions and the authors' closures, if any, which were presented during the calendar year. Each part is separately indexed by title on a multientry basis as well as by authors. All three parts contain over 431 papers and approximately 2,640 pages.

The member combination subscription to all three parts is $9, or $3 to any individual part. The nonmember subscription is $12 to all three parts, or $6 to any individual part. A combination subscription to any two parts is offered to nonmembers at $10. For nonmember orders to individual parts, 75¢ should be added to the subscription price for foreign postage, and both the subscription price and postage are payable in advance in New York exchange. For the combination nonmember subscription to any two parts, $1 should be added, and for the combination subscription to all three parts, $1 extra should be added for foreign postage. Both the subscriptions and the postage are payable in advance in New York exchange.

Discounts of 25% of the nonmember prices mentioned are allowed to college and public libraries. Publishers and subscription agencies are allowed 15% discount of the nonmember prices quoted. Please send all orders and remittances to: Order Department, American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y.

These volumes, bound in cloth, afford an excellent opportunity to start or enlarge a library. Volume 76 will be made available during March and April but the receipt of orders now is essential to assure receiving the volume of *Transactions* while the supply lasts.

Textile Conference Held at North Carolina State College

The Annual AIEE Textile Electrical Conference sponsored by the Textile Industry Subcommittee was held at North Carolina State College on November 14-15, 1957.

Cosponsors were the AIEE Carolina Section, department of electrical engineering, and the Extension Division of North Carolina State. The Conference Committee was under the co-chairmanship of Howard Strock, E. H. Gilliam Company, Charlotte, N. C., and J. H. Lampe, dean, School of Engineering, North Carolina State College, Raleigh, N. C. The chairman of the Textile Industry Subcommittee is R. B. Flowers, General Electric Company, Atlanta, Ga.

Attendance of 226 was the second largest in the history of the Conference and was about equally divided between mill operators, machinery manufacturers, and representatives of electrical manufacturers and power companies.

Features of the two-day Conference included 10 technical papers, an open forum on maintenance problems, luncheon and dinner meetings.

Tax Deductions Incurred in Society Activities

The following information has been received by Engineers Joint Council, and confirmed by their legal counsel as being correct:

The Internal Revenue Service under ruling *55-4, I.R.B. 1955-1* states that a taxpayer "who gives his services gratuitously to an association, contributions to which are deductible" under the relevant provisions of the Code "and who incurs unreimbursed traveling expenses, including the cost of meals and lodging, while away from home in connection with the affairs of the association and at its direction may deduct the amount of such unreimbursed expenses in computing his net income;" subject, however, to the limitation in respect to all gifts made to exempt organizations of this type; namely, that the total amount of such gifts made in any one year may not exceed 20% of the donor's gross income for such year. This limitation means that while such expenses are deductible they are included with other gifts in computing the 20% limitation.

Annual Cleveland Electronics Conference

The 5th Annual Cleveland Electronics Conference will be held at the Masonic Auditorium, Cleveland, Ohio, February 14-15, 1958.

The Conference is sponsored by the Cleveland chapters of the AIEE, Institute of Radio Engineers, Instrument Society of America, and Cleveland Physics Society, in co-operation with Case Institute of Technology and Western Reserve University.

Translations of USSR Scientific and Engineering Journals Now Available to AIEE Members

AS A SERVICE TO AIEE members, by arrangement with the Pergamon Institute, a nonprofit organization, the translations of four leading Soviet scientific and engineering journals in the fields of power transmission, communications, and electronics, are now available.

Scientific and engineering work in the Soviet Union has reached a high level of achievement. With the advent of "Sputniks" in recent months, interest in engineering education in the Soviet Union and in their scientific achievements has become intensified. In certain aspects of electrical engineering, the USSR is already in the front rank. For example, they are pioneering in d-c power transmission with associated developments of rectifier and inverter equipment and supervisory controls. The development of water power resources on a large scale implies developments in alternators, switchgear, and transmission systems. Noteworthy contributions are being made to the theory of automatic control and remote control based in part on past Soviet achievements in nonlinear mechanics. It has been estimated that over 80% of the Russian scientists can read English: whereas less than 5% of American scientists and engineers can read Russian. Now, for the first time, translations of four important journals are to be made available.

Following is a listing and prices of the publications available on an annual subscription basis:

Journals	List Price
(1) "Elektrischestvo" Electric Technology, USSR (quarterly)	$56 per year*
(2) "Radiotekhnika I Elektronika" Radio Engineering and Electronics, USSR (monthly)	$45 per year*
(3) "Radiotekhnika" Radio Engineering, USSR (monthly)	$30 per year*
(4) "Elektrosviaz" Telecommunications, USSR (monthly)	$30 per year*

*50% discount of list prices is available to AIEE Members and members of such other organizations as may be arranged.

The first publication, "Electric Technology, USSR," will be issued quarterly and contains only such articles in full as have been recommended for publication by the Editorial Advisory Board. The last three publications will be issued monthly and will contain the complete translations of the Soviet publications. This has been made possible for the Pergamon Institute by a grant from the National Science Foundation and in association with the Massachusetts Institute of Technology who have agreed to have the AIEE assist with the distribution of the journals and reviews to determine the quality of the work and its usefulness to science and industry generally.

In connection with "Electric Technology, USSR," the Pergamon Institute will make available the full translation of any article listed by title only or in abstract at a nominal charge of $4 per thousand Russian words or less depending upon the number of people ordering any given translation.

AIEE Technical Committees To Assist

Pergamon Institute through the assistance of the USSR Academy of Sciences will obtain page proofs and original illustrations of articles in advance of their publication in the Soviet Union. They will submit titles and abstracts of the articles and the complete translation when necessary to the AIEE technical committees who will assist in reviewing the quality and usefulness of the Soviet work to American scientists, engineers, and industry generally to determine what material should be translated and published.

Annual subscriptions and remittances for any of the foregoing publications should be sent to Secretary N. S. Hibshman, American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y.

Brochures of additional information will be furnished on request as available.

Sample Contents Lists

As illustrative, the following are the contents lists of two of the publications:

Electric Technology, U.S.S.R.—Contents Volume 1, 1957

Veits, V. I. An Interconnected Power Grid for the European Part of the Soviet Union.
Treshchev, I. I. Investigations of Variable-Speed A-C Machines.
Naidis, V. A. The Use of Amplidynes and Transistor Amplifiers for Industrial Drives.
Karaev, R. I. Short-Circuit Transients on Long Lines.
Belousov, M. M. Rates of Restriking Voltage Rise across Circuit-Breaker Contacts in Large Power Systems.
Roizen, S. S. Selection of Antihunt Transformers for Amplidyne Electric Drives.
Isaev, I. P. A Statistical Assessment of the Stability of Induction Motor Characteristics.
Alekseev, B. A. Impulse Testing of Turn Insulation on H. V. Machines.
Larionov, V. P. Voltage Gradients in Long-Spark Leader Channel.
Oslon, A. B. Measurement of Earth Resistances.
Shkliarskii, L. F. Automation of the Electric Drives of Bucket-Chain Dredgers.
Drozdov, A. D. Differential Protection Circuit with Magnetic Restraint.
Shramkov, E. G., et al. The Stability of Measuring Instruments Using Magnico and Alnico.
Shenkmann, L. Z. Effect of Exciter Saturation on Transients in Synchronous Machines.
Khu, Tszo. The Behaviour of Relay Protection on Unsynchronised Reclosing.
Bratkova, O. N. Mode of Operation of a Resistance Welding Machine with Energy Storage in the Magnetic Field.
Livshits, A. L.; Rogachev, I. S. Generators for Electric Spark Machining of Metals.

Radio Engineering and Electronics, U.S.S.R.—Contents Volume 2, No. 3, 1957

Editorial:

Kozhevin, V. E.; Loshkarev, V. E. The Effect of External Potential and Some Other Factors on Capacity Photo-Response of Semiconductors.
Liashenko, V. I.; Snitko, O. V. The Effect of Molecules and External Electrical Field on Photo-Conductivity of Semiconductors.
Chepoor, B. V. Photo-Electrical and Optical Properties of H_gJ_2.
Berlaga, R. J.; Rumsh, M. A.; Strakhov, L. P. Arising of Photo-EMF in Layers of Sulphurous Lead.
Politov, N. G. The Centers of Colouring in Crystals KCl and KCl with Admixture Ag.
Skvortzova, N. E. The Study of Input Resistances and the Control of Equivalent Scheme of Germanium Detectors in the Frequency Range of 1000-10000Mc/s.
Bouch-Brooevitch, A. M.; Soltamov, U. B. The Study of Transistor Characteristics with Oscillographic Characteriograph.
Bouch-Brooevitch, A. M.; Imas, J. A. Some Questions of Application of Semiconductors Bolometers.
Bogoliubov, V. E. New Modification of the Capacity Method for Measurements of Potential Difference and Its Application to the Study Contact Potentials of Semiconductors.
Lookirsky, A. P. The Vacuum X-ray Spectograph with Geiger Counter for Research in Power Levels of Solid Bodies.
Kondorsky, E. I.; Pakhomov, A. S.; Shiklosh, T. Theory of Spontaneous Magnetization of Ferrites.
Reinov, N. M.; Stelmakh, M. F. Temperature Dependence of Arbitrary Magnetization in Ferrites Co-Zn at Low Temperatures.
Varchenia, S. A.; Dorfman, J. G. Thermo-Electric Properties of Ferrites in the Range Close to Curie Temperature.

Brief Information:

Elinson, M. I.; Vasiliev, G. F. Experimental Research of the Field Emission of Hexaborid Lantan.
Demidov, K. K. Inertness of Internal Photo-Effect in Chlorous Silver.

Chronique:

Arenberg, A. G. (obituary)
International Colloquium on Actual Problems of Radio-Waves Propagation.
Interdepartmental Seminar on Cathode Electronics.

Critics and Bibliography:

Chechick, P. O. Publishers Schemes in the Field of Radio-Technic and Electronic for 1957.

Nominations Invited for 1958 Medal in E. E. Education

The Recognition Awards Committee announces that it is now ready to receive nominees for the 1958 AIEE Medal in Electrical Engineering Education which will be presented at the Fall General Meeting in Pittsburgh, Pa., October 26-31, 1958. Nominations must be received in the office of the Secretary of the Professional Development and Recognition Department, Mrs. A. Landres, located at AIEE Headquarters, not later than May 1, 1958.

The Committee invites members to submit names of nominees. Such nominations may be made by procuring a nomination form from the Secretary of the Professional Development and Recognition Department. The form should be accompanied by at least two supporting letters from others who are familiar with the accomplishments and the qualifications of the nominee. It is desirable that at least one letter come from a former student of the nominee.

All nominations received last year in

connection with the award of this medal will be considered by the Committee this year without further nomination. Supplementary information on these past nominees may, of course, be forwarded for attachment to the present file on these outstanding educators in electrical engineering education.

In accordance with the "Bylaws of the Medals Provided from the Members-for-Life Fund," the award will be based upon teaching excellence, ability to inspire students to higher achievements, contributions to the teaching of electrical engineering in textbooks and in writings on engineering education, active participation in the work of the professional and educational societies, and contributions to teaching and the profession through research, engineering achievements, and technical papers.

Conference Papers Open for Discussion

Conference papers listed below have been accepted for AIEE *Transactions* and are now open for written discussion until February 26. Duplicate double-spaced typewritten copies of each discussion should be sent to E. C. Day, Assistant Secretary for Technical Papers, American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y., on or before February 26.

57-87 **Some Measurements of Abnormal Corona.** *G. W. Penney, J. G. Hewitt, Jr.*
57-194 **Some Practical Mathematical Techniques.** *G. K. Carter*
57-675 **Relay Scanning Design Technique Generates High Accuracy and Speed in Analog-to-Digital Transducer Measurements.** *A. F. Kay*
57-922 **Magnetic Amplifier Design. Part I: The Core.** *R. E. Anderson*
57-963 **Analysis of Nonresonant Charging Circuit for Magnetic Pulse Generator.** *N. L. Weinberg*
57-990 **Transient Protection Conditions in Pipe-Line Stations.** *E. B. Turner*

Reprints may be purchased at 40¢ each to members 80¢ each to nonmembers, if accompanied by remittance or coupons. Please order by number and send remittance to: AIEE Order Department, 33 West 39th St., New York 18, N. Y.

Recent Activities of AIEE Philadelphia Section

The initial meeting of the Philadelphia Section's 1957-58 season was held in October and featured a talk on "Power for the Delaware Valley Area" by E. B. Shew, chief electrical engineer of the Philadelphia Electric Company. Mr. Shew stated that to meet the increasing demand for power, the Philadelphia Electric Company was spending at the rate of $1.75 million per week for its construction program. The company's all-time peak of 2,317 mva was attained during the summer of 1957. This was the first time the summer peak had exceeded the winter peak.

"Analog and Digital Computers" was the subject of the November Main Section Meeting which was held jointly with the American Society of Mechanical Engineers. Included was a demonstration of Philadelphia Electric Company's new nonlinear d-c analog computer. The computer is used primarily in connection with the company's gas and steam systems and has capacity for 284 pipe lines, 15 sources, and 83 loads. The speakers were: W. Shreve, Leeds & Northrup Co.; W. A. Gerhart, Radio Corporation of America; and L. McGinn, Franklin Institute.

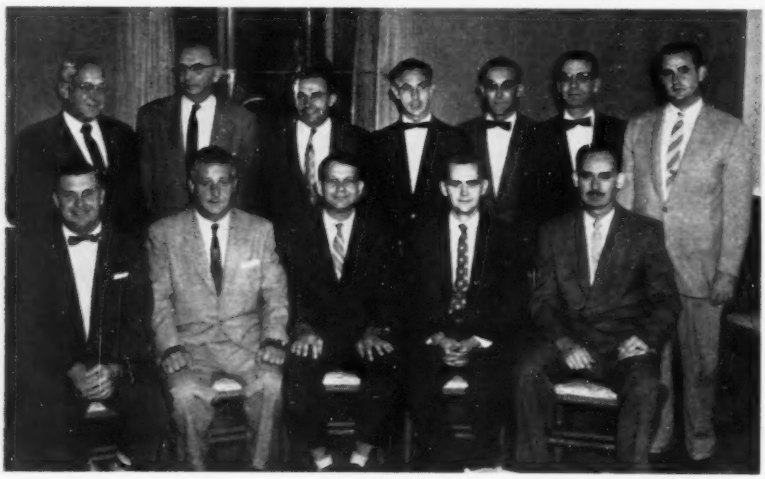
The Fall Inspection Trip to the American Telephone & Telegraph Company's (AT&T) new long distance sectional switching center at Wayne, Pa., attracted over 150 visitors. Arrangements for the trip were under the direction of B. B. Young of the Franklin Institute and chairman of the Section Educational Committee; F. W. Price, Westinghouse Electric Corporation; and J. J. Boone, J. B. Elby, and D. W. Bruch of AT&T.

R. L. Halberstadt, Bell Telephone Company of Pennsylvania, chairman of the newly organized Management Division of the Philadelphia Section reports that the enthusiastic response given the Division's first two meetings indicates a very definite need for this type of activity in the Philadelphia area. Dr. Bruce Dearing, dean of the School of Arts and Sciences, University of Delaware, discussed the "Development of the Middle Management Man" at the October meeting. The December meeting featured a talk on "Personal Factors in Management" by Dr. S. S. Kight, director of the Fels Group Dynamics Center at the University of Delaware.

The two remaining meetings for the year are: February 5, 1958, "Role Playing," C. H. Leeds, personnel training supervisor, Bell Telephone Company of Pennsylvania; and April 24, 1958, "Merchandising—The Salvation of Management," J. W. Cook, vice-president—merchandising, AT&T.

Other Division officers are: Vice-Chairman C. H. Rice, Westinghouse Electric Corporation; Secretary-Treasurer R. W. Henning, Bell Telephone Company of Pennsylvania.

East Central District Meeting



Hupco Photograph

COMMITTEE CHAIRMEN prominent in planning the AIEE 1958 East Central District Meeting to be held May 13-15 in Huntington, W. Va., are: (*seated, left to right*) H. M. Hayden, Boat Trip Committee; J. H. Reeves, Inspection Committee; R. W. Hinshaw, Registration Committee; R. D. Crippen, secretary; H. C. Willey, Technical Papers Committee; (*standing, left to right*) W. W. Kerr, vice-president of East Central District; P. C. Kelsey, general chairman; Carl Latta, Hotel Committee; H. P. Hagaman, Jr., Student Committee; W. R. Wagner, general vice-chairman; Jack Steelman, Jr., Dinner and Luncheon Committee; M. A. Fotos, Jr., Publicity Committee. Absent are Mrs. P. C. Kelsey, Ladies Committee, and E. B. Ellerbe, Finance Committee. Present plans for this meeting include presentation of approximately 60 original technical papers by engineers from all parts of the country, inspection tours of various industries in the Tri-State Area such as a tour of the new Kaiser Plant at Ravenswood, W. Va., and activities of interest to wives accompanying their husbands to the meeting. Entertainment being planned includes an evening river cruise on the steamer *Avalon* and a pre-meeting open house.

COMMITTEE ACTIVITIES

EDITOR'S NOTE: *This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.*

Communication Division

Data Communication Committee (A. E. Frost, *Chairman*; W. K. MacAdam, *Vice-Chairman*; H. F. Caley, *Secretary*). Although the Data Communications Committee was not officially established until August 1957, it joined with the Telegraph Systems Committee in sponsoring a technical session at the 1957 Summer General Meeting. Developments in the data field have come at a rapid pace and the Committee is planning future technical sessions which will keep interested AIEE members abreast of these developments. Of special interest in this respect is the session on SAGE System Communications scheduled for the Winter General Meeting.

Two problems in the transmission of data on which considerable work is presently being done are the attainment of higher speeds and greater accuracy. Through its membership, many of whom are closely associated with this work, the Committee keeps in close touch with latest developments in this field. Papers covering some of these developments are scheduled for joint technical sessions with the Telegraph Systems Committee and Computing Devices Committee at the Winter General Meeting.

The scope of the Committee has been defined as the treatment of matters in which the dominant factors are concerned with the organization and transmission of items of data over the various communications facilities to and from the data processing machines.

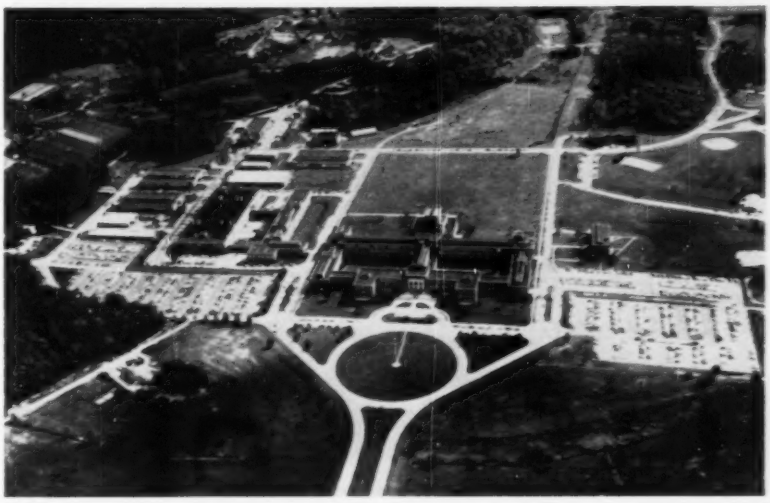
Because of the interrelation between data transmission and both the communication facilities and the data processing equipment, it is intended to continue working in close co-operation with the other technical committees in these fields.

Industry Division

Industrial Power Systems Committee (R. T. Woodruff, *chairman*; H. H. Angel, *vice-chairman*; A. C. Friel, *Secretary*). Activities of the Industrial Power Systems Committee are centering around the revision of the publication entitled "Interior Wiring Designs for Commercial Buildings." A meeting of the guiding committee was held in New York, N. Y., on December 12, 1957, for the purpose of considering material which had been prepared to that date. It is hoped that the revised publication, which will now be commonly known as the "Gray Book" will be ready for printing in 1958.

Much emphasis also is being placed on getting the "Red Book—Electric Power

Inspection Trip for District No. 2 Meeting



AERIAL VIEW of the Main Laboratory Buildings at the United States Naval Ordnance Laboratory, Silver Spring, Md., which will provide an interesting inspection trip for those attending the Middle Eastern District Meeting to be held in Washington, D. C., April 28-30, 1958.

Great Lakes District Meeting Committee

Photographic Laboratory, MSU

TAKING TIME OUT for a photograph is the committee in charge of the AIEE Great Lakes District Meeting to be held in East Lansing, Mich., on May 5-7, 1958. Pictured (*left to right*) are: J. A. Strelzoff, general chairman; R. R. Hoedel and R. J. Rentschler, Kellogg Center of Michigan State University (MSU); A. W. Rauth, finance; H. M. Hess, chairman Michigan Section; K. Norris, dinners; T. W. Culpepper, speakers; W. C. Peterson, hotel; H. G. Hedges, transportation; M. B. Rann, inspection trips; B. K. Osborn, registration; C. R. Jacobsen, program; M. A. Meleky, student activities; and Mrs. J. D. Ryder, ladies activities. Absent are M. C. Westrate and J. J. Fredrickson, chairmen of the program and publicity committees respectively. Headquarters for the meeting will be the Kellogg Center on the beautiful MSU campus. The program will include trips through the Oldsmobile plant and tours of the MSU campus.

M. S. Coover Receives Plaque from AIEE

DR. M. S. COOVER, administrative assistant to the dean of engineering, Iowa State College, receives plaque which reads "Presented to Mervin S. Coover in grateful appreciation for his services as the Sixty-ninth President of AIEE August 1, 1956 to July 31, 1957." The presentation was made at the November joint meeting of the Iowa Section of AIEE and the Iowa State College Student Branch. Among those present were: *(left to right)* Dr. R. M. Stewart, Jr., associate professor of physics; Gordon Held, electrical engineering senior and president of the Student Branch; Dr. W. B. Boast, head of the department of electrical engineering; Dr. Coover; R. C. Ringstrand, Northwestern Bell Telephone Company and president of the Iowa Section of AIEE; Dr. G. A. Richardson, associate professor of electrical engineering, faculty counselor of the Student Branch. Also participating in the presentation but not pictured was W. G. Kaldenberg, Iowa Power and Light Company and president last year of the Iowa Section of AIEE.

Los Angeles Section Meeting

Los Angeles Department of Water & Power Photo

THE LOS ANGELES SECTION OF AIEE was host to 28 past Section chairmen at an overflow dinner meeting on December 10, 1957. This meeting was the annual "Past Chairman's Night" and was sponsored by the Industry and Construction Division. Shown at the speakers table are *(left to right)* E. D. Barcus, vice-chairman, Los Angeles Section; L. A. Pascoe, program chairman; C. C. Jamison, vice-president and manager of the research department, Security-First National Bank, main speaker for the meeting; and Harry Lott, chairman, Los Angeles Section. Mr. Jamison discussed the future industrial and financial prospects of Southern California in his talk entitled, "Depression, Regression, or Another Readjustment."

Distribution Systems for Industrial Plants"—into the hands of more people who have use for it. To this end, study groups based on the "Red Book" are being promoted by various sections throughout the country and more are under consideration for 1958.

Power Division

Committee on Transformers (D. L. Levine, *Chairman;* C. W. Miller, *Vice-Chairman;* C. H. Bjorquist, *Secretary*). The work of the Committee is divided among seven Subcommittees; the following is a report of the activities of these Subcommittees.

Dielectric Tests Subcommittee: The Working Group on Power Factor Test Codes has completed a Proposed Code for Power Factor Testing of Mineral Oil-Insulated Instrument Transformers. It is now in the hands of the Standards Committee. The Working Group has begun preparation of a similar Code for dry-type transformers.

Concurrently with the continuing work on a Guide for Impulse Testing, another Working Group is studying the entire dielectric tests part of the Test Code. This work has been divided into two parts: short-range changes and additions; and long-range projects such as (1) development of a switching surge test, (2) possible modification of the low frequency test voltages, and (3) corona testing. A group of proposed revisions have been completed.

The Working Group on the Adequacy of Present Tests has been very active on the subject of transformer bushings, and recommendations have been approved in the Working Group. Liaison with the Switchgear Committee is being set up.

The question of the need for both power and distribution levels for certain equipment has been studied and will be published as a Committee Report.

The work on switching surges is in the initial stage.

Insulation Life Subcommittee: This Subcommittee is showing considerable progress in the preparation of formal Test Procedures for thermal evaluation of insulation systems for transformers. The procedure for ventilated dry-type power and distribution transformers was published for trial use as AIEE No. 65 (November 1956). Procedures for sealed gas-filled transformers, for liquid-immersed transformers, and for specialty transformers are in various stages of development.

Work is progressing satisfactorily on revising the short-circuit sections of the C57 Standards. Work on revising the Guide for Loading Oil-Immersed Distribution and Power Transformers (American Standard designation: Appendix C57.92), and on preparing a new Guide for Loading Dry-Type Transformers has been completed.

Other items under consideration include a Loading Guide for Furnace Transformers, a Loading Guide for Current-Limiting Reactors, methods for making temperature tests on dry-type transformers, methods for measuring ambient temperatures, a review of short-circuit requirements for step-voltage and induction-voltage regulators, and a study of insulation life of specialty transformers.

Insulating Fluids Subcommittee: The

proposed Guide for Maintenance of Insulating Oils has been approved by the AIEE Standards Committee, and has been published for trial use. The results of the questionnaire are nearly completed and will be analyzed, and material prepared for a suggested revision in the Guide in the near future.

The Proposed Guide for Maintenance of Transformer-Type Askarel is in the final draft stage.

Audible Sound Subcommittee: The Working Group on Technical Investigations has continued its work on methods for calculating noise versus distance, and will issue a report of two methods for making these calculations in the near future. Progress has been made on the use of wind screens on microphones as a possible means of co-ordinating readings between self-cooled and fan-cooled transformers.

Performance Characteristics Subcommittee: This Subcommittee has one Working Group which has been assigned the study of the use of impedance bridge methods for loss measurements in transformer testing, and has agreed: (1) to approve the inclusion in the ASA Transformer Standards the use of impedance bridge methods as an alternate for the measurement of transformer losses; and (2) the name to be applied to this method will be "Impedance Bridge Methods."

Standards Subcommittee: The Working Group on Arc Furnace Transformers, in co-operation with Foundry Equipment Manufacturers Association and National Electrical Manufacturers Association groups, has assisted in the preparation of proposals for Arc Furnace Transformer Standards, which includes standard kva ratings, standard voltage ratings and taps, and the use of reactors and their connections. Considerable progress has been made toward standardizing the voltage and current ratings of the low voltage winding. This is now ready for Committee ballot.

The Working Group on Regulators has prepared and circulated proposals for revisions in the Regulator Standards and Test Codes, including new sections on polarity and angular displacement. These are ready for ballot in the Committee.

The Working Group on Rectifier Transformers has prepared and circulated proposals pertaining to Rectifier Transformer connections, definitions, ratings, and Test Codes. These have been correlated with American Standard C-34 as proposed by by the Electronic Converters Committee.

The Working Group on Constant Current Transformers has circulated proposed revisions in the Standard and Test Codes for comments from the Working Group.

The Working Group on Potential Devices is assembling information on characteristics of devices now in use as the first step toward standardization.

West Coast Subcommittee: This Subcommittee reviews and comments on work of the main Committee and the various Subcommittees. Several projects have been initiated at the suggestion of the West Coast Group, and other activities have received an impetus because of West Coast interest.

The most active interest in discussions at Subcommittee meetings centers on such items as bushing tests, impulse testing, switching surges, insulating levels in the higher voltages, transformer noise and vibration, and corona or ionization tests.

Pittsburgh Section Smoker

SHOWN at the annual AIEE Pittsburgh Section Smoker are: (*left to right*) Dr. R. B. Teare, District No. 2 vice-president; A. A. Johnson, general chairman, 1958 Fall General Meeting; R. N. Wagner, Pittsburgh Section chairman, 1957-58; W. R. Harris, vice-chairman, Pittsburgh Section; L. W. Tarn, secretary-treasurer, Pittsburgh Section. The Smoker was the kick-off meeting of the Pittsburgh Section, which now numbers 1,562.

Science and Electronics Division

Solid-State Devices Committee (S. J. Angello, *Chairman;* A. C. Sheckler, *Vice-Chairman;* C. F. Spitzer, *Secretary*). The major contribution of the Solid-State Devices Committee is in the area of standards publication. Recently, a test code for transistors has been published as AIEE No. 425, August 1957. This document includes definitions, letter symbols, and point contact transistor test procedures. Work is under way on a companion standard for junction transistors. A document proposing graphical symbols for semiconductors is now before the Standards Committee. Task groups have been established to create letter symbols for diodes, test procedures for semiconductor diodes, and letter symbols and definitions in the field of thermoelectric devices.

Task groups are also working in the Dielectrics Subcommittee to cover nonlinear dielectric definitions in the field of electric surface charges utilization and formation, and electrophotic devices definitions.

AIEE FELLOWS ELECTED

Pierre Marcel Honnell* (M '46), professor, electrical engineering department, Washington University, St. Louis, Mo., has been transferred to the grade of Fellow in the AIEE ". . . for his contributions to electrical engineering in the fields of research and education." Dr. Honnell was born in Paris, France, on January 28, 1908. He earned his B.S. degree in E.E. at A & M College of Texas in 1930. This was followed after an interval of eight years—three years as a member of the technical staff, Bell Telephone Laboratories, Inc.; a year of study at the Technischen Hochschule in Vienna, Austria; and four years as a research engineer with the Geophysical Division of The Texas Company—by award of the E.E. degree

P. M. Honnell

* Dr. Honnell's transfer to the grade of Fellow was approved at the Board of Directors Meeting, October 11, 1957.

from Texas A & M. He received the M.S. degree from Massachusetts Institute of Technology in 1939 and from California Institute of Technology in 1940, and the Ph.D. from St. Louis University in 1950. Dr. Honnell's military service includes a period during which he was assigned to the United States Military Academy at West Point. There, as director of electronics in the department of chemistry and electricity, he introduced modern electronics at the U.S. Military Academy, and as part of that project, designed and supervised the installation of a very extensive laboratory for this subject. He was awarded the Legion of Merit in 1946 for meritorious service to the Academy. Dr. Honnell has taught electrical engineering at a number of universities, and for the past 10 years has been on the graduate faculties of Washington University, specializing in electronic and electromechanic network theory. He has been keenly interested in fundamental researches and he has made significant contributions to radio engineering and allied sciences. Dr. Honnell is a fellow of the American Association for the Advancement of Science, a senior member of the Institute of Radio Engineers, and a member of Sigma Xi, American Society for Engineering Education, and several other technical societies. Dr. Honnell has been an active member of AIEE, serving on the Executive Committee of the St. Louis Section and on the following AIEE Committees: Student Branches (1951-52), Basic Sciences (1954-57), and Computing Devices (1956-57).

AIEE PERSONALITIES

W. R. G. Baker (AM '19, F '47), vice-president, General Electric Company, (GE) Syracuse, N. Y., and one of the world's leading pioneers in the broad field of electronics has retired from the company. Simultaneously, Chancellor W. P. Tolley of Syracuse University announced that Dr. Baker has been appointed vice-president for research. In his new position, Dr. Baker will be responsible for directing the University's contract research program. The retirement notice stated that Dr. Baker was leaving the company "after more than 34 years of loyal and outstandingly effective service." For 15 of these

W. R. G. Baker

years (1941-56), he directed the company's electronics businesses as general manager of its Electronics Division. During this period, GE electronic equipment sales grew to exceed the sales volume of the entire company in 1939. During this period, the company also established its Electronics Park research and manufacturing plant on a 200-acre site adjacent to the New York State Thruway seven miles northwest of Syracuse, N. Y. The Park served until 1956 as the headquarters for all GE electronics business and Dr. Baker has maintained his headquarters there for the past 10 years. The division's 16 separate businesses and 5 electronics laboratories were reorganized into three electronics division—defense, industrial, and components—in June of last year when Dr. Baker was made a consultant to the company's executive office. During his career, Dr. Baker worked for and was honored by the nation's leading professional and business associations for his technical and administrative contributions to the electronics industry. He served as president of the Institute of Radio Engineers (IRE) in 1947; is currently serving a second term as president of the Electronic Industries Association and has received the highest awards granted by these groups—their medals of honor. He also has received the Army's Medal of Freedom citation. This was awarded in 1953 for advice and guidance to the Chief of Staff and to the Secretary of the Army, on the problems of utilization of electronic devices to the maximum extent in modern warfare. In March 1958 he will receive the Founders' Award of the IRE. Among his best-known contributions to the electronics industry were the organization and direction of two national television system committees which recommended engineering standards to the Federal Communications Commission, paving the way for commercial monochrome telecasting in 1941 and color television in 1953. The GE pioneer television station at Schenectady, N. Y., uses Dr. Baker's initials (WRGB) to identify the station—in recognition of his contributions not only to the company's television developments but to the entire industry. Dr. Baker has served on many AIEE Committees.

J. R. Hodnette (AM '25, F '42), vice-president and general manager (chief operating officer), Westinghouse Electric Corporation, Pittsburgh, Pa., has been named executive vice-president. Mr. Hodnette was chosen to receive the Edison Medal for 1957 (*Electrical Engineering*, January 1958, p. 86.).

E. S. Fields (AM '20, F '29, Member for Life), vice-president and general manager, The Cincinnati Gas & Electric Company, has been elected president and chief executive officer of the company. Mr. Fields has served on the following AIEE Committees: Membership (1933-37), Code of Principles of Professional Conduct (1945-52), Industrial Power Applications (1945-47), Board of Directors (1945-47), and Charles Le Geyt Fortescue Fellowship (1955-58). He served as an AIEE vice-president (1945-47).

W. J. Moulton-Redwood (AM '20, M '35, Member for Life), safety engineer, Algoma Steel Corporation, Sault Ste. Marie, Ont., Canada, was among 78 Canadians who were honored with the Order of St. John of Jerusalem, at an Investiture by His Excellency Governor General Massey of Canada. Men and women of all walks of life were invested with the Order which dates back to the Crusader's capture of Jerusalem in the year 1099. The Order is the oldest order of chivalry in the British Empire. Mr. Redwood was honored for his many years of public service through the St. John Ambulance Brigade. He is honorary treasurer and an active member of Division 87, located at the Sault Ste. Marie.

H. S. Kirschbaum (AM '43, M '51), associate professor, Ohio State University, has joined the staff of Battelle Memorial Institute, Columbus, Ohio, as a consultant in systems engineering research.

Ernst Weber (AM '31, F '34), acting president of the Polytechnic Institute of Brooklyn, has been elected president. Born in Vienna, Austria, Dr. Weber joined the faculty in 1930 as a visiting professor. In 1931, he accepted the permanent position of research professor of electrical engineering in charge of graduate study. Later, he

Ernst Weber

became head of the department of electrical engineering. In January 1957, he was named vice-president for research. Dr. Weber is a member of the Army Scientific Advisory Panel. He has served on numerous AIEE Committees. A pioneer in high frequency electronic research, the new president holds more than 50 American, Canadian, and British patents in the field of microwave techniques. During World War II he organized at Polytechnic a group of electronics experts who solved critical problems relating to radar. For this vital contribution to the war effort, Dr. Weber was awarded the Presidential Certificate of Merit.

J. L. Cross (AM '54), assistant sales manager of apparatus products, Westinghouse Electric Corporation, Pittsburgh, Pa., has been appointed industrial sales manager for the Westinghouse Atlantic apparatus sales region in Philadelphia, Pa.

R. N. Brown (AM '46), director of engineering, Kearfoot Company, Inc., Little Falls, N. J., has been elected vice-president and director of engineering.

F. H. Roby (AM '37, M '41), vice-president, sales, Square D Company, Detroit, Mich., has been elected a vice-president of the National Electrical Manufacturers Association.

J. E. Cordell (AM '54), sales manager, Southern States Equipment Corporation, Hampton, Ga., has been elected vice-president, sales. **T. A. Burdeshaw** (AM '49, M '57), Southern States engineering manager, has been elected vice-president, engineering.

P. M. Christensen (AM '38, M '44), director of applied research and engineering development for low-voltage products, Federal Pacific Electric Company, has been appointed to the new staff office of co-ordinator of engineering.

C. J. Zohn (AM '53), electrical engineer, in charge of administrative services for the Electronic and Radar Laboratories, Lockheed Missiles, has been promoted to manager of administrative services department of Lockheed Missile Systems' Research and Development Branch.

W. L. Wearly (AM '38, M '56), executive vice-president, Joy Manufacturing Company, Pittsburgh, Pa., has been elected president of the company.

L. L. Antes (M '45), in charge of the modern physics laboratory, Wright-Patterson AFB, Dayton, Ohio, has been appointed senior scientist, Hamilton Standard Electronics Department, Broad Brook, Conn.

E. F. Sixtus (AM '27, M '39), vice-president, Federal Pacific Electric Company, was honored with a 50-year certificate by the National Electrical Manufacturers Association.

W. G. Skinner (AM '56), in charge of development and engineering, Magnet Wire Section, General Electric Company, has joined the Essex Wire Corporation as manager of its Fort Wayne, Ind., Magnet Wire Plant.

W. H. Mutschler (AM '49, M '55), patents and standards engineer, Allis-Chalmers Manufacturing Company Pittsburgh (Pa.) Works, has been appointed chief engineer, succeeding **W. M. Terry, Jr.** (AM '48, M '55), who has been named to the new position of director of engineering co-ordination. Mr. Terry served on the AIEE Transformers Committee (1956-57).

E. W. Engstrom (F '49), senior executive vice-president of the Radio Corporation of America (RCA), has been named as recipient of the Industrial Research Institute (IRI) Medal for 1958. Dr. Engstrom, who joined RCA in 1930, has been senior executive vice-president since October 1955. As the director of RCA's television research during the 1930s, he was responsible for the development and construction of equipment and for the planning and co-ordination which led to the development of television. Continuing in charge of research for the corporation during the 1940s, he was primarily responsible for the organization, growth, and activities of RCA Laboratories, which was established as a separate division of RCA in 1942 at Princeton, N. J. The presentation of the medal to Dr. Engstrom will take place next May at the annual meeting of the IRI in Colorado Springs, Colo. Dr. Engstrom has served on the AIEE Lamme Medal Committee, 1954-57.

G. W. McLaren (AM '49, M '56), sales representative in the Portland, Oreg., district of Allis-Chalmers Manufacturing Company Industries Group, has transferred to Allis-Chalmers Boston (Mass.) Works as an application engineer.

A. A. Tiezzi (AM '42), product planner, Specialty Capacitor Section, General Electric Company, Hudson Falls, N. Y., has joined the field engineering department of the Sprague Electric Company, North Adams, Mass., as product specialist on d-c paper and film dielectric capacitors.

A. C. Munster (AM '54), executive engineer, Research Division, Philco Corporation, Philadelphia, Pa., has been appointed associate director of research. Mr. Munster has served on the AIEE Basic Sciences Committee, 1954-57.

R. L. Van Allen (AM '53), electronics scientist, U. S. Naval Research Laboratory, Washington, D. C., has been appointed head of the Circuit Research Section, of Control, a Division of Magnetics, Inc., Butler, Pa. Mr. Van Allen will concentrate on research and development of transistor-magnetic circuitry for industrial control applications.

OBITUARIES

Carl Lee (AM '13, M '21, Member for Life), retired, died recently. Mr. Lee was born March 12, 1891, in Comanche, Texas. In 1911, he graduated as an electrical engineer from the University of Texas. From 1913 to 1940, he served as electrical engineer for Peabody Coal Company. He became chief engineer in 1940, and remained in that position until his retirement in 1953. During World War I, he served as 1st Lieutenant and later as Captain, 111th Engineers, 36th Division, in France. Mr. Lee served on the following AIEE Committees: Applications to Mining (1925-36, chairman 1928-31); Meetings and Papers (1928-31); Standards (1929-31); Industrial Power Applications (1938-40).

Winford G. Milne (AM '21, Member for Life), retired managing director, N. Slater Company, Ltd., Hamilton, Ont., Canada, died recently. Mr. Milne joined N. Slater Company in 1920 when the late Norman Slater was president of the company. Mr. Milne's first responsibility was that of works superintendent, and later he became chief engineer and managing director. Mr. Milne and Mr. Slater were pioneers in their chosen branch of the electrical industry, embracing pole line hardware and specialties for the central station and communications industries. Mr. Milne held patents to many electrical and mechanical items. Retiring two years ago, he continued to act as a director of the firm until his death. Mr. Milne was a member of the Association of Professional Engineers of Ontario, the Engineering Institute of Canada, and was a contributing member to the Canadian Standards Association.

Harry Whitney Osgood (AM '07, M '22, Member for Life), retired, died recently. Mr. Osgood was born May 24, 1883, in Sterling, Mass. He graduated from Worcester Polytechnic Institute in 1905. The following year he joined Stone & Webster as an electrical engineer. From 1917 to 1919, he was electrical engineer for the design and construction of Hog Island Shipyard. From 1919 to 1921, he was electrical engineer for plant construction of the Bethlehem Shipbuilding Corporation and during 1921 was plant engineer for the Fore River works. He then went into business for himself as a consulting engineer. Mr. Osgood was an active member of the Washington Section of AIEE. He served on the following AIEE Committees: Marine (1918-19), Standards (1928-32), Edison Medal (1936-41), and Protective Devices (1936-38).

Charles Leo Smith (M '49), secretary-treasurer, International Association of Electrical Inspectors (IAEI), and electrical field engineer, National Fire Protection Association (NFPA), died recently. Born January 22, 1908, in McLean County, Ky., Mr. Smith had been engaged in various phases of the electrical industry since the age of 12, when he became an electrical helper in Evansville, Ind. He was employed by the City of Detroit in the Detroit Fire Department, the Department of Parks and Boulevards, and the Water Supply Department, before enlisting in the United States "Sea Bees" in 1942. In 1946, he entered the Electrical Inspection Department in Detroit. He became secretary-treasurer of IAEI in 1948. Among other things, Mr. Smith was editor of the National Electrical Code, and editor of the *News-Bulletin*, official publication of the IAEI. He was a member of the International Municipal Signal Association, International Brotherhood of Electrical Workers, and Society of Fire Protection Engineers. Mr. Smith served on the AIEE Safety Committee (1952-54, 1955-57).

Clifford Allen Smith (M '45, M '51), chief electrical operator at Mustang Generating Station, Oklahoma Gas & Electric Company (OG&E), died recently. Mr. Smith was born in Anthon, Iowa, in July 1894. He attended Oklahoma City

University, and received the E. E. degree from the International Correspondence Schools. In 1916, Mr. Smith was employed by the Oklahoma Railway Company. In 1928, he joined OG&E as plant electrician at the Belle Isle Station. He became a member of the Relay Department in Oklahoma City in 1930, and in 1948 moved to Horseshoe Lake as chief electrical operator for the plant. A year later he was named chief electrical operator at the Mustang Station.

MEMBERSHIP

Recommended for Transfer

The Board of Examiners at its meeting of December 19, 1957, recommended the following applications for transfer. Any objection to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections must be furnished and will be treated as confidential.

To Grade of Member

Allentuck, J., general engineer, U. S. Atomic Energy Comm., New York, N. Y.
Amato, J. P., engineer, The Hartford Electric Co., Hartford, Conn.
Asmus, J. R., supervisory electrical engineer, Electrical Section, International Engineering Co., Inc., San Francisco, Calif.
Baptist, J. V., supervisory electrical engineer, Electrical Design Section, U.S. Bureau of Reclamation, Denver Federal Center, Colo.
Berndt, V. M. (Miss), engineer, Blackstone Valley Gas & Electric Co., Pawtucket, R. I.
Blumenthal, A., lead designer, electrical dept., Singmaster & Breyer, New York, N. Y.
Bradley, R. O., director of engineering, Toledo Scale Co., Toledo, Ohio
Camp, H. F., project engineer, General Engineering Div., The Fluor Corp., Ltd., Los Angeles, Calif.
Campbell, E. F., supervisory engineer, transmission lines, engineering dept., Iowa Power & Light Co., Des Moines, Iowa
Caudill, J. D., sales engineer, Westinghouse Electric Corp., Louisville, Ky.
Chambers, E. H., protection engineer, system protection dept., Pacific Gas & Electric Co., Oakland, Calif.
Compton, H. O., vice-president & technical director, Porto Rico Telephone Co., San Juan, Puerto Rico
Conolly, M. D., engineer, engineering dept., Public Service Co., Maywood, Ill.
DeSieno, C. F., senior engineer, American Gas Electric Service Corp., New York, N. Y.
Dill, E. C., engineer, East River Electric, Madison, S. Dak.
Ferguson, W. H., Jr., sponsor engineer, industry engineering dept., Westinghouse Electric Corp., East Pittsburgh, Pa.
Giantvalley, J. R., group engineer, Ryan Aeronautical Co., Lindberg Field, San Diego, Calif.
Grimm, J. O., electrical engineer, Electrical Branch, Design Div., U. S. Bureau of Reclamation, Denver Federal Center, Denver, Colo.
Harris, E. R., electrical engineer, Power Branch, U. S. Bureau of Reclamation, Sacramento, Calif.
Hayden, J. R., senior planning engineer, electric system planning dept., Public Service Co. of Colorado, Denver, Colo.
Herr, C. E., design engineer, Westinghouse Electric Corp., Greenville, Pa.
Higgins, T. D., utilities engineer, Union Carbide Chemicals Co., Charleston, W. Va.
Houck, J. P., senior electrical design engineer, Westinghouse Electric Corp., East Pittsburgh, Pa.
Hough, R. R., assistant chief engineer, operations & engineering dept., American Tel. & Tel. Co., New York, N. Y.
Howard, R. C., chief of advance engineering, Servomechanisms, Inc., Hawthorne, Calif.
Hunkins, H. D., supervisory electrical engineer, Electrical Design Branch, U. S. Bureau of Reclamation, Denver Federal Center, Denver, Colo.
Hunter, T., district engineer, transmission & distribution dept., Duquesne Light Co., Pittsburgh, Pa.
Jacoby, George V., research engineer, research dept., Minneapolis-Honeywell, Brown Instruments Div., Philadelphia, Pa.
Johnson, W. B., supervisory electrical engineer, Electrical Branch, U. S. Bureau of Reclamation, Denver Federal Center, Denver, Colo.
Kanitz, D. R., application engineer, General Purpose Control Section, Square D Co., EC & M Div., Cleveland, Ohio.
Koncel, E. F., Jr., engineer I, system planning dept., Commonwealth Edison Co., Chicago, Ill.
Kult, M. L., associate professor, electrical engineering, University of Akron, Akron, Ohio
Kyle, H. A., Jr., area supervisor, Electrical Lab. & Test Branch, Tennessee Valley Authority, Rogersville, Tenn.
Lappi, T., supervisory electrical engineer, Electrical Branch, U. S. Bureau of Reclamation, Denver Federal Center, Denver, Colo.
Lee, G. S., senior engineer, electrical dept., Sverdrup & Parcel, Inc., San Francisco, Calif.
Lokay, H. E. Jr., distribution engineer, electrical utilities engineering dept., Westinghouse Electric Corp., East Pittsburgh, Pa.
May, R., power plant electrical engineer, Toledo Edison Co., Toledo, Ohio
McCoy, E. K., building & equipment engineer, general engineering dept., The Ohio Bell Telephone Co., Columbus, Ohio
Miller, A. D., senior engineer, electrical engineering dept., Public Service Co. of Colorado, Denver, Colo.
Peebles, J. D., electrical project engineer, power dept., Stearns-Roger Mfg. Co., Denver, Colo.
Pryor, T. S., general superintendent, South Texas Cotton Oil Co., Corpus Christi, Texas
Richardson, P. E., supervisory engineer, design Div., Electrical Branch, U. S. Bureau of Reclamation, Denver Federal Center, Denver, Colo.
Risch, R. F., general manager, Northeast Nebraska Rural Public Power District, Emerson, Neb.
Schatz, E. R., assistant dean, College of Engineering & Science, Carnegie Institute of Technology, Pittsburgh, Pa.
Schwalb, W. R., electrical engineer GS-12, Electrical Branch, U. S. Bureau of Reclamation, Denver Federal Center, Denver, Colo.
Sedam, C. H., manager of station construction, general construction dept., Pacific Gas & Electric Co., San Francisco, Calif.
Snedegar, R. R., electrical engineer, Roanoke Division Engineering, Appalachian Electric Power Co., Roanoke, Va.
Taber, L. S., head of Engineering Division, Fall River Electric Light Co., Fall River, Mass.
Weber, G. W., supervisor, Control Engineering Administration Unit, General Electric Co., Lawrence Park, Pa.
Weiser, L. G., sales engineer, apparatus sales dept., Westinghouse Electric Corp., Louisville, Ky.
Whitlam, G., technician, engineering dept., Ontario Hydro, Toronto, Ont., Canada
Wilson, A. V., engineer, electrical distribution engineering dept., Public Service Co. of Colorado, Denver, Colo.
Woodcock, R. E., engineer, station design dept., Consumers Power Co., Jackson, Mich.
Wohlford, J. G., director, Co-operative Div., Georgia Institute of Technology, Atlanta, Ga.
Woodworth, J. L., engineer, communications products dept., General Electric Co., Syracuse, N. Y.
Yost, A. G., development engineer, Ohio Brass Co., Barberton, Ohio

56 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership in the grade of Member have been received from the following candidates, and any member objecting to election should so notify the Secretary before February 25, 1958, or April 25, 1958, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Ahearn, J. J., test engineer, sr., AVCO-Research & Adv. Development Div., Lawrence, Mass.
Altieri, V. J., job engineer, Bechtel Associates, New York, N. Y.
Bailey, R. E., Idaho transmission & protection engineer, Moutain States Tel. & Tel. Co., Boise, Idaho
Battey, L. J., sales engineer, General Electric Co., Salt Lake City, Utah
Bollinger, A. J., consulting electrical engineer, Ebasco International Corp., New York, N. Y.
Bremner, A., Jr., transmission specialist, Idaho Power Co., Boise, Idaho
Brown, C. B., manager, Duke Power Co., Charlotte, N. C.
Chesseldine, I.H.B., senior electric engineer, Merz & McLellan, Toronto, Ont., Canada
Creegan, G. A., electrical engineer, Metcalfe Hamilton Grove Co., Istanbul, Turkey
Crossley, H. R., general superintendent of power, Irving Pulp & Paper Ltd., Lancaster, N. B., Canada
Dobbs, C. L., 311 Virginia St., New Orleans, La.
Dodge, E. F., chief engineer, J. L. Metcalf & Co., Inc., Seattle, Wash.
Donnelly, G. M., meters & services specialist, Boise, Idaho
Farley, W. S., Jr., field engineer, Philadelphia Electric Co., Philadelphia, Pa.
Fruhner, E. T., systems engineer, American Tel. & Tel. Co., New York, N. Y.
Gaefke, W. F., network supervisor, Duquesne Light Co., Pittsburgh, Pa.
Griffin, J. A., group leader, North American Aviation, Inc., Los Angeles, Calif.
Harvey, W. E., director of research & product development, John C. Dolph Co., Monmouth Junction, N. J.
Head, H. T., engineer, A. D. Ring & Associates, Washington, D. C.
Herman, H., assistant chief, communications-electronics, USAF, Maxwell Air Force Base, Ala.
Johnson, E. F., general superintendent, Southern Nevada Power Co., Las Vegas, Nev.
Johnson, R., project engineer, B. C. Power Commission, Victoria, B. C., Canada
Jolley, C. A., Jr., district engineer, Southern Bell Tel. & Tel., Asheville, N. C.
Lowe, V. W., chief engineer, Heap & Co. Ltd., Manchester, England
Lucas, H. R., instrument transformer engineer, Canadian General Electric Co., Toronto, Ont., Canada
Madden, R. M., senior design engineer, General Electric Co., Hudson Falls, N. Y.
McCannel, H. R., sales engineer, General Electric Co., Chicago, Ill.
McCormick, W. J., assistant electric district superintendent, Consumers Power Co., Saginaw, Mich.
McQuarrie, A. M., advance development engineer, General Electric Co., Somersworth, N. H.
Moore, H. R., superintendent of power, Idaho Power Co., Boise, Idaho
Ochs, R. H., senior product engineer, International General Electric Co., New York, N. Y.
Papanou, D. S., engineer, Western Union Telegraph Co., New York, N. Y.
Power, T. H., superintendent, Utilities Div., Gulf Oil Corp., Port Arthur, Texas
Price, R. F., electrical engineer, Stearns-Roger Mfg. Co., Denver, Colo.
Sawyer, A. I., operating engineer, Idaho Power Co., Boise, Idaho
Schlottmann, F. W., engineer, Consolidated Edison Co. of N. Y., Inc., New York, N. Y.
Schultz, G. J., supervising engineer, Commonwealth Edison Co., Glencoe, Ill.
Stretch, J. W., product engineer, General Electric Co., Schenectady, N. Y.
Thomas, W. T., manager of engineering, Ajax Electrothermic Corp., Trenton, N. J.
Williams, J. A., application engineer, John C. Dolph Co., Monmouth Junction, N. J.
Yeomans, L. O., engineer, American Tel. & Tel. Co., White Plains, N. Y.

41 to grade of Member

ELECTRICAL ENGINEERING EDUCATION

AIEE in Northeastern University

THE AIEE STUDENT BRANCH at Northeastern University, Boston, Mass., was granted its charter in 1922 with 70 students in electrical engineering. The Joint Student Branch of AIEE-Institute of Radio Engineers (IRE) was chartered in July 1950. Currently, there are more than 700 students enrolled in electrical engineering, attending Northeastern under the co-operative plan of education.

Recently, the University dedicated Hayden Hall, a four-story $1.8 million building, which is the new home of the electrical engineering department among others.

Advisers to the student branch are Prof. R. I. Carter (AIEE) and Prof. J. S. Rochefort (IRE).

Fay Foto Service, Inc.

An Electrical Engineer's World—1957

S. B. INGRAM
FELLOW AIEE

WE ARE LIVING in the world of electronics and atomic energy, the jet airplane, the guided missile, the earth satellite, the digital computer, the automatic factory, and, unfortunately, the hydrogen bomb. I have set myself the task of talking about that part of this amazing world which belongs to the electrical engineer. I would like to start by drawing a picture of the electrical engineer's world of today as I see it and to finish by drawing some very general conclusions as to the preparation a young electrical engineer should have before he is launched on his career in this world.

Having selected as my subject the electrical engineer's world, I would like to make my first point, and that is, that there is really no such thing as an electrical engineer's world, there is only the world of nature. We always have to keep in mind that the division of engineering in the formal organization of the engineering profession, in engineering societies, and in engineering schools, is an arbitrary one and does not correspond to anything real in nature. Nature respects no such arbitrary divisions as those between electrical engineering and mechanical engineering or in fact between engineering and science. The problems which the engineer has to solve are just problems and their solution can be reached by applying the forces of nature to the service of man, which is a good definition of engineering and which you will note says nothing about the categories of engineering or the unreal distinction between engineering and science.

When the engineer is faced with a problem to solve, he generally will find that its complete solution requires the application of several disciplines. Of course, this is not true of trivial problems, but if the problem is a major one, like the design of a new airplane, a nuclear reactor, a guided missile, an earth satellite, an electronic computer, or a submarine telephone cable, it probably will involve problems of electrical engineering, mechanical engineering, and materials and metallurgy. The systems studies will involve the techniques of operations research or systems engineering, statistics, and engineering economy. The environmental conditions under which the system will operate may lead the designer into the fields of oceanography, meteorology, or upper atmosphere physics. Add a dash of mathematics, not just calculus and ordinary differential equations but modern algebra, numerical analysis, statistical decision theory, and design of experiments, and one has some idea of the real world of nature in which the electrical engineer is going to have to operate.

What then do I mean when I select as a theme for my talk, "An Electrical Engineer's World?" Well, there are, of course, many major problems, the core of whose solution falls within the discipline of electrical engineering. Primarily, they are electrical problems and it is this complex of problems which will be considered to make up the electrical engineer's world for the purposes of this address. What are its general characteristics? They have been changing rapidly during recent years. What are they in 1957?

A Research and Development World

You are all familiar with the exponential nature of the rate of technological progress. There is no sign of it levelling off or saturating. Instead, it seems to go up ever more steeply. One speculation on the reason for this is that we have learned the technique of what Dr. M. J. Kelly likes to call the systematic method of research, of the massive deployment of creative resources in the attack on technological problems. Research and development used to be small scale hit or miss, speculative efforts. No longer is this

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S. B. Ingram is director of education and training, Bell Telephone Laboratories, Inc., New York, N. Y.

Electrical Engineering Education

so. Today, research and development undertakings are well-organized, strongly supported, strategic campaigns conducted by carefully organized armies of well-trained scientists and engineers, directed toward well-defined technological objectives. The results are fully as predictable as the results of a military campaign. Our knowledge of the nature and the magnitude of the problem to be solved corresponds to the knowledge which a military commander has of the strength and disposition of the enemy forces. This knowledge enables us to assign scientific forces of appropriate strength and character and within the limits of the uncertainties of the fortunes of war we are able to count on the outcome of the campaign. I would like to suggest that this mastery on our part of the technique of the systematic method of research has brought about a revolution in technology comparable in magnitude to the industrial revolution and accounts for the increased rate of technological progress of the last two decades. Let me cite some examples. Take the atom bomb for instance. It is unfortunate that the most obvious examples seem to be military ones but it is also a fact that it has been under the great pressure of military necessity that we have invented and perfected the technique of the systematic method of research on the largest scale. Therefore, let us consider the example of the atom bomb. When Hahn and Meitner discovered nuclear fission in 1939, it was obvious to every informed physicist that here lay the possibility of the generation of power by atomic means or, if generated suddenly enough, of man-made explosions of hitherto undreamed of magnitude and violence. The possibility was brought to the attention of Pres. F. D. Roosevelt, a technological army was assembled as the Manhattan District, and, in 1945, the explosion of the first atom bombs over Nagasaki and Hiroshima definitively brought the war in the Far East to a sudden conclusion.

Another example is radar. The research efforts of many industrial and Government laboratories, with the Radiation Laboratory at Massachusetts Institute of Technology serving as a focal point of the co-ordinated effort, produced a rate of advance in this branch of communications technology which was unlike anything that personnel in the communications field had experienced up to that time, and which in the short space of a half decade established the field of microwave electronics as a mature technology.

With a growing appreciation by industry and Government of what could be accomplished by the application of the systematic method of research, there is a growing emphasis on the research and development sector of all engineering effort. It is a little difficult to document this because there is an inherent uncertainty in research and development statistics arising from the arbitrariness of the definition of just what constitutes research and development. There are very good figures on the current situation taken from a recent study by the National Science Foundation (NSF). This survey indicates that as of 1954, of the 550,000 engineers and scientists employed in private industry about 30% are in research and development. When an attempt is made to trace the rate of growth of research and development, less satisfactory statistics are found because the comparative figures from earlier years do not exist in the same form. For the 1941-52 period, the National Manpower Council in its 1953 report estimated that the number of scientists and engineers employed in research (and development) approximately doubled. During this same period, figures compiled by the NSF and the Bureau of Labor Statistics enable us to estimate that the total number of scientists and engineers in the United States increased by only 76%. In any case, it seems clear that research and development activity is increasing somewhat more rapidly than engineering as a whole.

A Digital World

In that part of the electrical engineer's world having to do with the handling of information, digital techniques have assumed an increasing importance. These have been popularized and glamorized in the last decade by the electronic digital computer and its many applications. Of course, these did not start with the digital computer. An old fashioned telegraph man feels himself on familiar ground in much of modern data processing. He has been coding his information and transmitting it in digital form for as long as he can remember. Those in the telephone business have been in the digital field as far back as the earliest automatic telephone switching systems and have been in it on a large scale, too, inasmuch as telephone switching systems form a substantial part of the field of telecommunications. Nevertheless, the growth of the electronic digital computer has expanded the area of application of digital techniques to practically all of the field of electrical engineering and far beyond it to other branches of technology and to the nontechnical areas of business accounting, statistics, and even language translation. Furthermore, with the various communications systems employing pulse modulation, digital technique have invaded the transmission part of the communications field. In fact, with time division multiplex, and similar systems, the once well-established boundary between transmission and switching in communications is becoming very indistinct. I, therefore, think it is fair to say that in the electrical engineering world people are experiencing a digital revolution.

A Feedback World

A large part of the electrical engineer's world, which does not depend on digital techniques, depends on negative feedback. Negative feedback was an important concept when it was applied to the amplification of small signals in the electronic amplifier. It is the cornerstone in the structure of broad band carrier telephone systems which form the basis for our nation-wide and world-wide communications systems today. But with the application of negative feedback to electromechanical systems in the servomechanism, we have the basis of most of the systems of automatic control.

The replacement of the human operator by the automatic control in production processes is proceeding rapidly and has now been dignified by the addition of a new word to the English technical language—"automation." I do not know of a definition of the word automation which has the sanction of authoritative standardization, but much of the usage of the term considers it properly used only in the case of those systems using feedback from output to input as an essential part of the control process. Because many production processes are mechanical and most controls are electrical, there is in automation one of the best examples of the welding together of two fields of engineering—electrical and mechanical. With the digital processing of data and the introduction of the electronic computer into the control process, a perfect example is given of the close integration of engineering disciplines. This should be thought-provoking to educators asking themselves the question, "For what sort of a technological world are we preparing these young engineers?"

A Statistical World

I do not know whether the electrical engineer's world of today is any more statistical than it used to be because, actually, it has always been statistical. However, I am sure that this awareness of its statistical nature is much keener than it used to be, and we have come to realize what a powerful tool exists in statistical methods. In the field of communications, for example, consider modern communication theory and two of its principal elements—noise and information theory. The basic concepts of both of these are statistical. Noise, by definition, is random in character and random processes can only be treated by statistical methods. Information theory is based upon the concept that the signal to be transmitted originates in a source which can be determined by making a statistical study of the totality of signals generated by that source.

Another application of statistics, or rather of its twin the theory of probability, to communications is the traffic problem in telephone switching systems. An important part of the design of any switching system is to achieve a suitable compromise between an economically wasteful design which contains an excess of alternate paths at every stage of the switching network so that the system never becomes fully loaded even under peak traffic conditions, and an underdesigned system which is unable to handle peak traffic conditions without imposing delays in the setting up of connections between the terminals. This is a problem of optimization and very frequently problems of optimization in engineering turn out to be statistical problems.

The traffic problem mentioned is not a new one in telephony. In fact, it goes back to the earliest days of the art. However, there are two recent examples which illustrate the important role which statistical methods play in the modern design of large electrical communications systems.

The *L3* carrier system is a broad band wire communication system on coaxial cable. The repeaters are negative feedback amplifiers with a spacing of four miles. A transcontinental *L3* route would contain about 1,000 repeaters in tandem. The system is, of course, equalized for gain and phase. The art of feedback amplifier design has reached a high stage of sophistication and, fortunately as is well known, a negative feedback amplifier can be designed so that its characteristics are relatively insensitive to the variations in the characteristics of the vacuum tubes and of many of the other electronic components from which it is built. In a transcontinental route of the type under consideration, the circuit contains about 5,000 tubes. It also contains some passive components, some 2,000 input and output transformers which are not included in the feedback loop of the amplifiers and which for this reason are more of a problem in practice than the tubes. You can readily appreciate that in such a system design techniques are being pressed pretty close to the limit. In *L3* they would indeed have exceeded the limit had advantage not been taken of the randomness of the distribution of component characteristics attainable when the manufacture of the components is carried on under conditions of statistical quality control. If, for example, all of the vacuum tubes of the *L3* system were to have transconductances on the minimum limit or on the maximum limit, the system would not work and would not be expected to work. But, if the manufacturing processes and maintenance procedures assure that the 5,000 tube transconductances are statistically distributed between maximum and minimum limits, with the peak of the distribution in the middle of the range, circuit requirements can indeed be met in the system. Requirements on randomness of characteristics have, therefore, been specified on *L3* components and careful statistical quality control of characteristics is an essential manufacturing requirement. The *L3* system provides a good example of an important application of the methods of statistical quality control to an electrical engineering problem.

The *TD2* system is a broad band microwave radio relay system. The repeaters are spaced at intervals of approximately 30 miles. The propagation characteristics of the medium are subject to variations or fading. These incidents of fading are characterized by varying depths and durations and may be correlated with meteorological conditions, time of day, and season of the year. The frequency, the depths, and the duration of the fades are important design parameters of the system. In the first transcontinental system, about 100,000 man-hours were devoted to accumulating transmission data of this type. Even then, the data could be taken only on a statistical sampling basis. Such an experimental program is obviously expensive. It is highly important that the experiment be planned and the data so taken that the statistical results derived are of maximum significance. This is the exact objective of the relatively new branch of mathematics which is of great importance in engineering known as the statistical design of experiments. The *TD2* system provides a good example of its practical application.

A Systems Engineering World

The impact of the systematic method of research on our technology was discussed earlier. The systematic method of research is, of course, a method which applies to large complex problems and many of today's problems are large and complex. They can be solved only by the development of systems of great magnitude. The very magnitude of these systems demands that their development be undertaken only after the most careful preliminary engineering studies. The branch of engineering activity which concerns itself with the making of these studies is called systems engineering.

There are various aspects of these systems engineering studies. Studies must be made of operating conditions and needs in the field and these are continually changing in an expanding and developing economy. A set of system requirements must be formulated on the basis of these operating needs. Various possible systems must be conceived and compared with due regard to the feasibility of their development in the present state of the art and to the economics of their ultimate manufacture and operation. Because the systems are complex, many variations and alternatives must be considered and many problems of optimization must be solved. The final result of these studies is a plan for a development project. However, the need for the systems engineering function does not

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Servolab Unit

ONE ANSWER to the challenge to up-grade training of young scientists in U. S. colleges and universities was unveiled recently by the Servo Corporation of America, New Hyde Park, N.Y., at a special meeting of professors of electrical engineering from the New York metropolitan area. Henry Blackstone *(left)*, president of Servo and Prof. G. B. Ruble of Rutgers University inspect the new Servolab (registered trade mark) unit, specially designed for university laboratories to instruct students in the design of self correcting systems for automatic control of production lines and control systems for military use. A complete installation is on the way to the Alabama Polytechnic Institute and other schools have placed their orders. The new unit is a smaller version of the Servolabs used by the military and industry and will enable student engineers to gain first-hand experience of the actual problems they will be called on to tackle in future years. Servo Corporation of America is the leader in design and manufacture of electronic automation equipment and infrared radiation detection and measurement systems for defense and industry.

Electrical Engineering Education

cease with the initiation of a development project. As development proceeds, the function is required to guide the project and to modify the original program in the light of knowledge obtained and experience gained during the course of the development.

Since systems engineering is a field of growing importance and many electrical engineers will end up doing systems engineering, the question may well be asked as to what kind of an engineer is needed to do this type of job and how he should be trained to do it. He should, of course, have a good technical background in his field because by the very nature of his job he is required to range back and forth and from start to finish over the whole of a complex project. He should have breadth of training and breadth of interest. He should be a generalist rather than a specialist. He should have a good background in mathematics including statistical methods. Inasmuch as his job is a co-ordinating job, he should be a good team worker because his job is not one which he can do by going off into a corner and doing it by himself. He is going to be dealing with people all the time. Above all, he must be able to communicate in speech and in writing. Inability to communicate is a serious handicap for any engineer but it is fatal for a systems engineer.

Conclusion

This then is one man's view of the electrical engineer's world as it exists today. It is a research and development world. It is a digital world. It is a feedback world. It is a statistical world. It is a systems engineering world. And, finally, it is scarcely a world at all because it is only an arbitrarily and perhaps unrealistically defined segment of the real world of nature. What should we give these young electrical engineering students who are going to venture into it? I am not going to attempt to answer this question except in the broadest terms because it is the purpose of this conference to seek the answer. I will, however, attempt to draw some general conclusions which I hope you will agree are logical if you are able to accept the picture of the electrical engineer's world as I have drawn it.

First, if the electrical engineer is going to have to cross the boundaries of his own little world, he had better be given the things which are common to all branches of engineering—lots of mathematics and basic science. Engineering is like a tree. It has a complex branching structure but everything in the structure shares the same firm roots in basic science. The engineer's education should, at every point, enable him to see how the branches spring from the roots.

Second, if the electrical engineer's world is as digital and as statistical as presented here, it is not going to be a world made up solely of nice continuous functions which can be handled by means of the elegant processes with which such functions can be treated. Algebra in modern form and arithmetic and numerical methods loom up much larger in importance than formerly. Above all, the engineer should realize that the world in which he will be living is not always a nice, regular, repeatable one. After carefully devising a neat experiment, he will frequently find that the results are erratic because he does not have all the important variables under control. Much of this effort will be devoted to getting the solution to these elusive variables. Frequently, the answer will not be a simple, satisfying yes or no but something like this: If I do so and so, I can expect such and such to happen 99 times out of 100, and if I go to twice as much trouble, or expense, it can be made to happen 999 times out of 1,000. Young engineers enter industry rebelling at the thought of a dirty, statistical, real world because it is not the nice, regular, fictitious one they have learned to accept in textbooks. Perhaps there are some things which could be done in the engineering courses to prepare them for the engineering world they will find. This can be done most particularly in their laboratory courses. Every laboratory course should be a practical course in statistics, the significance of measurements, and the analysis of data.

Finally, since this is a systems engineering world, it would be nice to give the young engineer some concept of what is involved in this important area of engineering activity. Even to do it on a modest scale may be asking too much of undergraduate education but it may be possible to make a start. Basically, the job of systems engineering is to study a situation, to define a problem, and to propose a method for its solution. Too often, in undergraduate education, we begin with the third step. The professor defines the problem and the student plugs in the facts he has learned, operates on them by the methods he has been taught, and cranks out the answer. It is essential that students be made to realize the necessity for defining problems to be solved by studying the needs of the situation. Anything that can be done toward achieving this aim will be of considerable value to student engineers in bridging the gap between the classroom and the real world of engineering.

Cooper Union Aided by Electrical Industry Committee

A special committee representing the electrical industry in New York, N.Y., has been formed to provide financial aid for professional education.

The group, taking its cue from President Eisenhower's plea for industrial support of higher education, will undertake initially to support the Centennial Development Program of The Cooper Union for the Advancement of Science and Art, according to H. A. Webster, president of T. Frederick Jackson, Inc., and chairman of the Electrical Industry Committee.

Funds will be raised to help with the construction of The Cooper Union's proposed new engineering school building at Astor Place and Fourth Ave., New York, N. Y. The committee's program was announced at a $125-a-plate dinner at the Waldorf-Astoria on January 16, 1958, when the proceeds of the dinner were presented to The Cooper Union.

The Cooper Union was chosen to be the beneficiary of the committee's effort because of its free-tuition policy and its program of selecting unusually talented students for free college instruction in engineering, Mr. Webster said.

Serving as co-chairmen with Mr. Webster are: Armand D'Angelo, commissioner of the New York City Department of Water Supply, Gas, and Electricity; Henry Fischbach, president of Fischbach and Moore; and Harry Van Arsdale, Jr., business manager of Local Number 3 of the International Brotherhood of Electrical Workers. M. M. Becker, president of the Standard Switchboard Corporation, is treasurer of the committee. D. B. Haring of Hatzel and Buehler, Inc., is secretary. The committee, as presently constituted, includes about 50 other officials of companies within the electrical industry.

AIP Program Aims To Improve Physics Teaching

Dr. Elmer Hutchisson, director of the American Institute of Physics (AIP), announced recently that a program to help improve the quality and quantity of physics taught in high school and college has been inaugurated.

This AIP program is being conducted in collaboration with the American Association of Physics Teachers (AAPT) and the American Physical Society with the support of the Fund for the Advancement of Education and the National Science Foundation.

This educational plan, which has important implications for the teaching of science in America, has the following objectives:

1. To make the study of a basic course in physics a "must" for every secondary school student.

2. To encourage qualified young people to seek careers in physics.

3. To evaluate the feasibility of teaching physics to large numbers of students by the use of television and color motion pictures despite the extreme shortage of science teachers.

4. To assess the increasing need for physicists in a technological society and to strengthen physics instruction in high schools and colleges for nonscience majors.

In order to achieve these objectives, the AIP has added two visiting college professors to its staff. They are Prof. G. O. Gale, on leave from the physics department of Grinnell College, Iowa, and Prof. W. C. Kelly, on leave from the physics department of the University of Pittsburgh.

Prof. Gale is making a nation-wide survey to determine how effectively television and motion pictures can be used

to provide physics teaching where none now exists, and to supplement and strengthen the effectiveness of present physics teachers at the school and college levels.

Dr. Kelly, in co-operation with the AAPT, which is a member society of the AIP, administers a new program of visiting lecturers in physics. This lectureship program is bringing some of the nation's most distinguished physicists, including Nobel Prize winners, to over 100 colleges which ordinarily do not have contact with these eminent scientists.

Other important activities being undertaken by Dr. Kelly are: co-ordination of various committees of AIP member societies concerned with physics education, encouragement of the study of physics by stimulating the growth of student sections of the AIP, increasing student memberships in physics societies, and development of regional groups of physicists.

Both Prof. Gale and Dr. Kelly are studying the manpower needs now and in the future for physicists in education, Government, and industry. They are concerned, too, with the task of providing more incentives for scientific education and information to all students in school and college regardless of their majors or principal areas of study.

Reactor Demonstration Housed at Franklin Institute

The drive for more students of science and engineering is being assisted, at the Franklin Institute, Philadelphia, Pa., by means of an atomic-reactor demonstration. This exhibit, which has recently been seen under the Leeds & Northrup sign at engineering meetings, is now installed in its own room at the Franklin Institute, with chairs for the audience, and demonstrations handled by the staff.

Now called "Atoms from Kilowatts," the demonstration shows how electric power may one day come from atomic energy, using a reactor as a boiler to supply turbo-generator steam. A large mock-up of the reactor core shows the generation of "steam," the action of the instrument-directed control rods, and the supply to the mock-up of the turbine. The instruments and controls are the same as those selected for about three fourths of the country's automatically regulated reactors, and they are fed with signals that cause them to operate exactly as they would on a genuine unit. Included also are the more important instruments for the turbine, generator, and transmission system.

New General Engineering Program at Antioch College

Antioch College inaugurated in the Fall of 1957 a new program in general engineering with a curriculum approved recently by the Engineers' Council for Professional Development, vice-president W. B. Alexander, dean of the faculty, has announced.

The new curriculum provides a broader and deeper base in the engineering sciences, Dr. R. A. Voelker, head of the department, explained.

The engineering department previously has offered a bachelor of science degree with a major in either civil, mechanical, or electrical engineering, but because of specialization, each major has lacked the depth of the new general engineering curriculum. Students, however, if they choose, may still select the former program, Dr. Voelker said.

The new engineering program of the college will continue to place strong emphasis on general education in the social sciences and humanities, and participation in the college's study-plus-work program.

Jobs of students in the engineering department range through drafting, production, design, research, and development at the junior engineer level.

A recent study of engineering graduates at the college from 1921 to 1954 shows little hedge-hopping among them. Some 92% have remained directly in the field, and 14% have earned graduate degrees. Graduates of this decade are doubling that percentage, Dr. Voelker said, with either earned advanced degrees or work currently under way in graduate schools for 28% of them.

Dr. Voelker himself directs the advanced work in civil engineering, Dean Kimball is in charge of advanced work in electrical engineering, while D. J. Myatt directs students in mechanical engineering.

Electrical Engineering Education

An Electrical Engineer in Education

L. V. BEWLEY (AM '27, F '47), dean, College of Engineering, Lehigh University, Bethlehem, Pa.

"The AIEE is important to me as an educator for at least 10 reasons:

"1. As the primary means, through its Journal, papers, discussions, and Transactions, for the authoritative dissemination of the latest developments in the theory and practice of electrical engineering.

"2. As an outlet for the publication of new ideas and reports in its field.

"3. As a meeting ground, through its local and national meetings, for the presentation and discussion of ideas.

"4. As a permanent record, through its Transactions, of the development and growth of electrical engineering.

"5. As a means, through its many operating committees, of organizing the purposeful development of electrical engineering and guiding that development along rational and beneficial channels.

"6. As a means, through appropriate committees, of setting up effective and proper standards, definitions, and codes to govern the design, manufacture, and operation of equipment.

"7. As a means, through its prizes and honors, of recognizing outstanding achievement in the profession.

"8. As a means, through its Journal, of keeping track of personalities in the profession with respect to their activities, promotions, shifts in location, changes in status, and accomplishments.

"9. As a means, through its National and local meetings, of meeting and associating with numerous other engineers, and in particular seeing and hearing and becoming acquainted with the leaders in the field of electrical engineering.

"10. As a means, through its Student Branches, of interesting young students in the meaning and dignity of the profession, to the end that they will become more deeply motivated as students and develop into better engineers."

Prof. Bewley received the B.S. degree in E.E. from the University of Washington in 1923, and the M.S. degree in E.E. from Union University in 1928. He was associated with the General Electric Company from 1923 to 1940, after which he joined the faculty of Lehigh University where he has served as professor and head of the electrical engineering department, dean of engineering.

The author of some 60 published papers and articles and several books, Prof. Bewley was awarded the AIEE Pittsburgh Section Best Paper Prize in 1930, and the AIEE National Best Paper Prize in Theory and Research in 1932. He received the Coffin Award from the General Electric Company in 1934. Prof. Bewley is a member of the American Society for Engineering Education.

During World War II, he organized and was commandant of the first USAR School.

Electrical Engineering Education

NCE Starts Nuclear Graduate Program

The appointment of Dr. S. E. Malaker as professor of nuclear engineering has been announced by Dr. R. W. Van Houten, president of Newark College of Engineering (NCE).

According to Dr. Van Houten, "Dr. Malaker's appointment is a most important step in our development of a program of courses in nuclear science and engineering. The increase in applications of nuclear energy is making demands on the engineering profession that can only be resolved by the education and training of specialists in this field. The college hopes, through its program, to assist industry in the development of these specialists."

The program in the Graduate Division was initiated during the Fall semester with the announcement of four courses: Technology of Nuclear Materials—a study of the properties of materials related to reactor design and construction and the disposal of fission product; Modern Physics —a study of the wave and particle nature of light, matter, and energy; Nuclear Physics—an introduction to atomic physics; and Elements of Nuclear Engineering—a study of nuclear reactors, nuclear fission, and nuclear theory.

Although Dr. Malaker will be a member of the college's department of physics and will teach both undergraduate and graduate courses, he will also serve as chairman of a faculty committee to develop a further program of education in nuclear science and engineering to satisfy the needs of graduate students, and engineers in industry.

Alumnus Establishes Scholarships at Pratt

An alumnus, eager to encourage gifted engineering students to continue their study of the sciences, has now established special scholarships at Pratt Institute, it was announced by Dr. R. F. Oxnam, president of Pratt Institute.

H. D. Belock, who attended evening classes at Pratt and later became a licensed professional engineer as well as the founder and president of the Belock Instrument Corporation, College Point, N.Y., is the donor of four special scholarships. These are to be awarded to talented engineering students at Pratt who need financial aid.

"In these days when national interests are concerned with earth satellites and turn to science for the solution of many problems including those of outer space, I believe we should all join in assisting talented young men," Mr. Belock advised Dr. Oxnam. "I know Pratt has the type of advanced engineering-science curriculum to develop scientists for the future. Lack of money should not deter ability." Dr. Oxnam reports, "It is a great help to receive these scholarships because approximately 50% of the students graduating from high school in the upper half of their classes are unable to attend college because of financial reasons."

Mr. Belock, who has been named a charter member of the Pratt Engineering School Industrial Council, founded Belock Instrument in 1950.

Fellowships Available in Traffic Engineering

The Bureau of Highway Traffic (BHT) at Yale University predicts great strides in the field of highway transportation during the next 10 years.

Recent developments in the scientific study of traffic operations include the use of high-speed computers in the planning and design of streets and highways. New methods of traffic research are possible through the use of these computers which simulate traffic movements throughout road networks and at complex intersections. Through the application of simulation techniques, the conflicts and delays in traffic may be measured and analyzed in the laboratory where a variety of different solutions are tested before new highway construction or traffic regulations are employed.

Electronic controls capable of detecting instantaneous traffic demands at the focal point of traffic congestion are being perfected to create the utmost in traffic operation efficiency. Electronics may also be utilized to replace human judgment in the operation of motor vehicles so far as safety is concerned.

The vast highway construction program, along with urban renewal, to be completed within the next decade will have a marked effect on the pattern of urban living. Highway and regional planning will develop new concepts of the relationships of transportation to urban sociological and economic factors. Additional research and the application of technical skills will be employed to obtain the greatest benefits from highway and renewal investments.

Inasmuch as the complexities of modern traffic require scientific treatment, cities and states will seek, in increasing numbers, the results of traffic research and the services of professional traffic engineers. The demand for traffic engineers already exceeds the rate of their graduation from colleges and universities.

The BHT made these statements along with the announcement of fellowships available to qualified graduate engineers who are citizens of the United States and would like to enter the profession of traffic engineering as a career. The fellowships cover a full academic year of graduate study, starting in September 1958 and terminating the following May. They provide a living stipend of $1,400 disbursed at the rate of $175 per month for a period of eight months, while a student is enrolled. The fellowships also provide the

CBC Student Branch Receives Charter

RICHARD BARRETT (*left*), chairman of the AIEE Memphis Section, presents an AIEE Affiliate Branch Charter to Thomas Lechner (*center*), chairman of the Student Branch at Christian Brothers College (CBC). Observing the presentation are Fred White (*second from left*), secretary of the Student Branch; Lewis Heyman (*second from right*), secretary of the Memphis Section; and William Nabholz (*right*), treasurer of the Student Branch.

tuition of $600, which amounts to a total value of $2,000 for each fellowship. The fellowships are made available to the BHT through grants from the Automotive Safety Foundation, the Esso Safety Foundation, The Liberty Mutual Insurance Company, and The James S. Kemper Foundation.

In addition to the fellowships, the BHT offers tuition scholarships to qualified municipal and state highway engineers who will receive salaries from their employers while undertaking the graduate work. This arrangement is considered by many employers to be a form of in-service personnel training.

The academic year of study offered by the BHT consists of two full semesters of classroom work, laboratory and individual research, required reading, field problems, and seminars. The courses include (1) traffic characteristics and measurements, (2) traffic regulations and control devices, (3) highway planning, (4) highway location and geometric design, and (5) highway administration and finance. Traffic experts from all over the country are invited to speak as guest lecturers at frequent intervals.

Applications for admission and fellowships may be obtained by writing to F. W. Hurd, director, Bureau of Highway Traffic, Yale University, Strathcona Hall, New Haven, Conn. The closing date for filing applications is March 1, 1958. Previous experience in traffic work is not essential to become a successful candidate for a fellowship or scholarship when high academic qualifications are indicated.

"Education and the Atom" Exposition at Union College

More than 6,000 secondary school and college students, as well as adult members of the community, attended a 5-day atomic energy exposition at Union College in Schenectady, N. Y., October 25-30, 1957.

The Exposition was opened by W. S. Cole, the newly elected director of the new Atomic Energy Agency in Vienna, Austria, who received an honorary degree on the occasion, together with Admiral Lewis Strauss, chairman of the Atomic Energy Commission (AEC).

Speaking at the opening convocation, Admiral Strauss foresaw that the forces which led to the splitting of the atom and the launching of "Sputnik" would turn out to be "the effective unifying force among men." He said that the "Atoms for Peace" Agency, which Mr. Cole heads, offered a means for bringing about world disarmament.

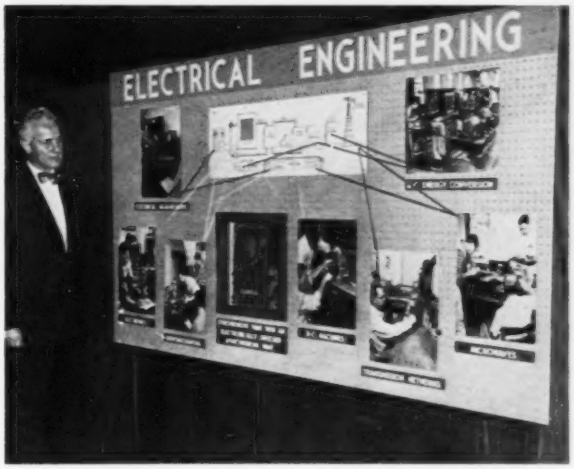
On exhibit in Union College's 35,000-square-foot Field House were the AEC's huge traveling "Atoms for Peace" exhibit; "Industry and the Atom," an exhibit prepared by General Electric Company (GE) and ALCO Products, Inc., of Schenectady; and "The College and the Atom," an exhibit prepared by Union showing the role of the liberal arts and engineering college in the atomic age. Included in the AEC's exhibit were various types of model reactors used in generating power for electrical generating stations. The GE exhibit consisted of a working model of the world's largest all-nuclear power station being built by GE for the Consolidated Edison Company of Chicago, Ill., and the Nuclear Power Group, Inc. The 180,000-kw station is under construction 50 miles southwest of Chicago and completion of the station is scheduled for 1960.

One of the more popular college exhibits was a simultaneous translation display used to emphasize the importance of communication between nations in the world today. The equipment was that actually used by the United Nations and was loaned to the College by International Business Machines Corporation.

Electrical Engineering Education

The display prepared by the electrical engineering department at Union showed the various electrical engineering skills required to design and build atomic energy electrical power plants.

ONE OF THE 6,000 visitors to the "Education and the Atom" Exposition at Union College tries her hand at the popular "mechanical hands" exhibit. Looking on are one of the regular student operators of the exhibit and the Atomic Energy Commission's exhibit manager.



THE HONORABLE W. S. COLE (*above, left*), director general of the new International Atomic Energy Agency, examines one of the Union College engineering displays at the College's five-day "Education and the Atom" Exposition. *Above, right:* Prof. Walter Lowen, chairman of the Division of Engineering at Union College, explains to a group of youthful visitors how atomic energy is converted into electric power. The display forms a section of the Atomic Energy Commission's "Atoms for Peace" show, part of the College's "Education and the Atom" Exposition, held October 25-30, 1957. During the five days that it was open, more than 6,000 people visited the Exposition.

Electrical Engineering Education

University of Texas Has Active Student Branch Program

The University of Texas Student Branch of AIEE–Institute of Radio Engineers (IRE) went all out this year in an attempt to enroll all junior and senior students of electrical engineering in AIEE.

During the 1957 Fall registration, a table was set up so that all electrical engineering students could be told of the advantages of membership in AIEE and be urged to join. As a part of the orientation program for new students, the AIEE-IRE Branch was host to the electrical engineering freshmen. During this meeting, G. E. Schmitt (F '49) gave a very stimulating talk urging student participation in the professional societies.

At the second meeting of the semester, J. W. Rittenhouse, chairman of the Student Branches Committee of AIEE, presented a spirited talk on the professional conduct of engineers. At a later meeting, Prof. Fred Bullard, well-known geologist, discussed the topic "Utilization of Volcanic Energy," which he illustrated with movies and slides. Other noted speakers have been engaged for the remaining meetings in this semester.

Interest in the coming Student Papers Contest is stimulated by a special committee to encourage and assist the preparation of suitable papers.

A very active committee is busy carrying out the program designed to keep track of graduates after they have left the University.

A full social program has been developed this semester. The Student Branch held the first party and dance at one of Austin's private clubs. Dancing to a lively combo was the order of the evening while refreshments were served to the 175 students and guests present.

Informal gatherings at the counselor's home are often held so that future plans and programs can be discussed. Altogether, this semester bids to be one of the most successful for the Student Branch at the University of Texas.

Science Fair To Be Held at NBS Boulder Laboratories

The doors of a Government laboratory will be opened wide again this year to receive scientific exhibits prepared by the youth of two Rocky Mountain states.

Dr. F. W. Brown, director of the Boulder Laboratories of the National Bureau of Standards (NBS), has disclosed that the committee for the third annual bi-state Colorado–Wyoming Science Fair has accepted his invitation to hold the Fair again in these laboratories.

The date set for the event is April 12, 1958. At this time, the top junior and senior high school science students will compete for bi-state honors.

Sponsors of the Fair are the Colorado-Wyoming Academy of Science, the Colorado Engineering Council, and the Colorado State Medical Society.

Dr. Brown said that the laboratories are being made available again this year, because "scientists here believe the past two fairs have been powerful tools for channeling young peoples' interest in science and mathematics along constructive lines."

Pointing to the Soviet Union's phenomenally rapid advance in technology, the science-administrator said, "These recent events have forcibly called everyone's attention to what scientists have long noted—United States education's frequent failure to capitalize on students' fascination with the wonders of science. The ultimate result is a shortage of well-trained scientists and engineers."

"Too often," he said, "we leave children to enjoy the fruits of technology and fail to guide them when they ask 'why.' Instead of challenging them to seek answers and to explore deeply frontiers of thought, we stifle their thinking with stereotyped and superficial instruction."

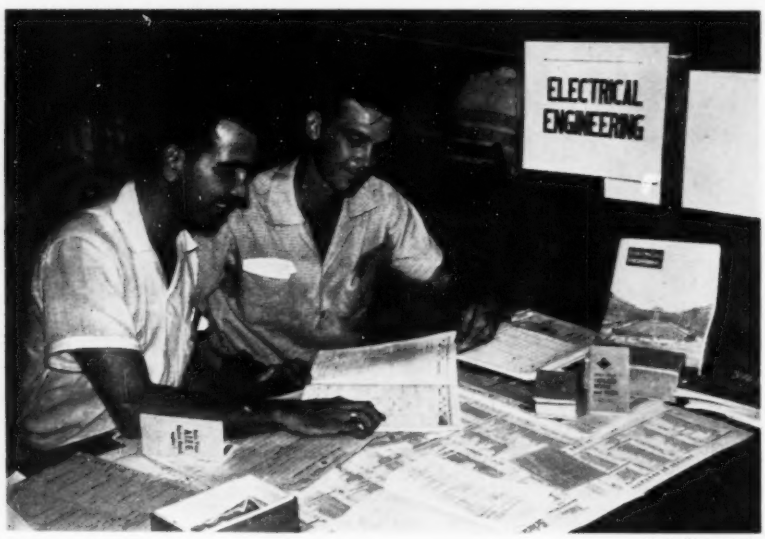
Dr. Brown lauded science teachers who stimulate their students to carry out original experiments. He termed them "the unsung heroes of our technical age."

"The science fair is actually their day of recognition even though they always seem to stay pretty well in the background," he commented.

EIC Releases Survey of Engineering Registration

The Engineering Institute of Canada (EIC) has recently released the results of its annual survey of engineering registration at Canadian universities and colleges. The tabulations have been prepared from lists obtained directly from the university registrars, and they were compiled at EIC Headquarters in Montreal, Que.

As usual, the figures are interesting, and close examination of them will reveal some significant facts. Total enrollment in engineering courses in Canada shows an increase of 12%, which is almost exactly the same rate of advance as one year ago. In actual numbers, 14,247 students are now studying engineering, as



Dart Photography

THE TOWER *(left)* **is a land mark at the University of Texas, Austin, where an active year-long Student Branch program is under way. Above: Don Evans** *(left)*, **points out to Kevin Torline the advantages of joining the AIEE during the Fall Student Branch registration at the University of Texas.**

compared with 12,723 in the Fall of 1956. This should not cause any excitement, although it is a good healthy increase.

Of more importance perhaps are the indications provided by the figures for the new freshman intake. These show an encouraging over-all upward trend of 13%, and the new classes of the western universities have again stolen the spotlight. Registration in engineering in the four western provinces has climbed rapidly in the last several years, at a faster rate than in the East—the rather startling fact is that this year 36% of all freshmen engineers in Canada have enrolled for study west of the Ontario–Manitoba border. Toronto, as expected, came up with the largest new class, 690 strong, followed by Alberta with 476, British Columbia third with 473, and Saskatchewan next with 464. In all, 5,132 new engineering students signed up in Canada this year.

There are some new names in the survey this year. Canada now has four more educational institutions offering at least a partial engineering course of recognized standing. These four are Sir George Williams College in Montreal, McMaster University in Hamilton, Waterloo College in Waterloo, and Assumption University in Windsor. Their entry into this field should be greeted with enthusiasm, and educators everywhere will wish them success.

A comparison of the popularity of the different courses, as disclosed by the new survey, shows no important change. Civil engineering remains first choice in total enrollment with 1,935 students, followed by electrical engineering with 1,539, and mechanical engineering showing 1,355. This is the same order as last year, with electrical engineering pulling away slightly from mechanical engineering as compared with the 1956 figures. Interesting signs of the industrial times in Canada are given by the strong steady increases again this year in the numbers taking up studies in petroleum engineering and engineering physics.

As a forecast, and discounting casualties between now and next graduation, 2,130 young engineers can expect to complete their courses and enter the profession in the spring of 1958. This will be an increase of almost 17% over the previous figure, and is perhaps the brightest part of the picture.

Lincoln Foundation Announces Design Competition

The James F. Lincoln Arc Welding Foundation's annual mechanical and structural design competition offers 46 cash awards to undergraduates. Top award is $1,250. Awards are made in two separate competitions, one for mechanical designs and one for structural designs. Open to undergraduates only, the competition offers awards for the best designs of a machine, machine part, structure, or structural component which makes a significant use of welding. Designs made as a part of regular school work may be used. Entries may be submitted after graduation or close of the school term. Rules are available from The James F. Lincoln Arc Welding Foundation, Cleveland 17, Ohio.

AEC Fellowships In Industrial Hygiene

Scientists and engineers with bachelor's degrees are being invited to apply for special Atomic Energy Commission (AEC) fellowships in industrial hygiene—a field of particular interest to the AEC because of its close relationship to the atomic energy program.

Administered for the AEC by the Oak Ridge Institute of Nuclear Studies, the one-year fellowships lead to a master's degree from either Harvard University or the University of Pittsburgh. Course work varies with the university selected and the interests and background of the individual.

Basic stipend for industrial hygiene fellows is $2,500 for 10 months, plus tuition, fees, and travel and dependency allowances. Maximum age for applicants is 35.

Detailed information concerning these fellowships, and application blanks are available from the Industrial Hygiene Fellowship Office, Oak Ridge Institute of Nuclear Studies, Oak Ridge, Tenn. Deadline for application is March 1, 1958.

Nuclear Engineering Program Announced by Nuclear–Chicago

A nuclear engineering program for colleges and universities has been announced by Nuclear–Chicago Corporation. The complete "package" includes not only a completely equipped nuclear engineering laboratory, instructions, and detailed student and group experiments, but also offers help to the school in obtaining funds and materials from the Atomic Energy Commission (AEC).

The heart of the Nuclear–Chicago package is a small, water moderated, natural uranium subcritical reactor. This is the first time a reactor of this type has been made commercially available. The inherent safety and simple construction of this versatile, easily maintained unit make it ideally suited for teaching purposes. Designed to fit into a typical school laboratory, the reactor consists of a 6 foot high, 4 foot wide stainless steel tank containing 435 gallons of tap water which act as moderator and shield. Immersed in the water is a lattice of 275 watertight aluminum tubes containing natural uranium fuel in the form of 1-inch by 8-inch slugs. In the center of the structure is placed a neutron source of an adequate flux level. The source, which may be polonium or plutonium mixed with beryllium, can be moved about within the reactor for experimental purposes. The whole structure, in operation, weighs somewhat less than 5 tons.

Unlike a critical unit, the student reactor eliminates any hazard of a runaway, needs no complicated shielding, costly cooling system, special buildings or involved safety program.

Electrical Engineering Education

Although the reactor is available as a separate unit, related nuclear detecting, measuring, and recording instrumentation is needed for optimum educational purposes. With the reactor, Nuclear–Chicago makes available a complete nuclear engineering laboratory, which has been carefully planned to provide for a wide range of group and student experiments. A partial list of some of the more important instrument groupings includes: (1) student radioactivity detection and counting systems, (2) gamma-ray scintillation spectrometer assemblies, (3) systems for measuring neutron flux in the reactor itself, (4) an automatic strip foil analyzer for determining exponential neutron flux throughout the reactor lattice, and (5) portable health monitoring systems.

A manual describing in detail more than 30 experiments using the reactor and instrumentation is supplied with the package program.

The Model *9000* Subcritical Reactor and all of the nuclear instrumentation provided in the complete package lie within the categories designated by the AEC as typical items of education and training equipment for which the AEC will consider giving financial assistance. The uranium and neutron source are available to schools without charge from the AEC. The instrumentation, subcritical reactor (without fuel), outline, and experiments are priced below $30,000 complete.

Installation of the first subcritical reactor from the initial Nuclear-Chicago production run will be made on the Evanston campus of Northwestern University to be used in their nuclear engineering curriculum.

Rockefeller Grant for Harvard School of Public Health

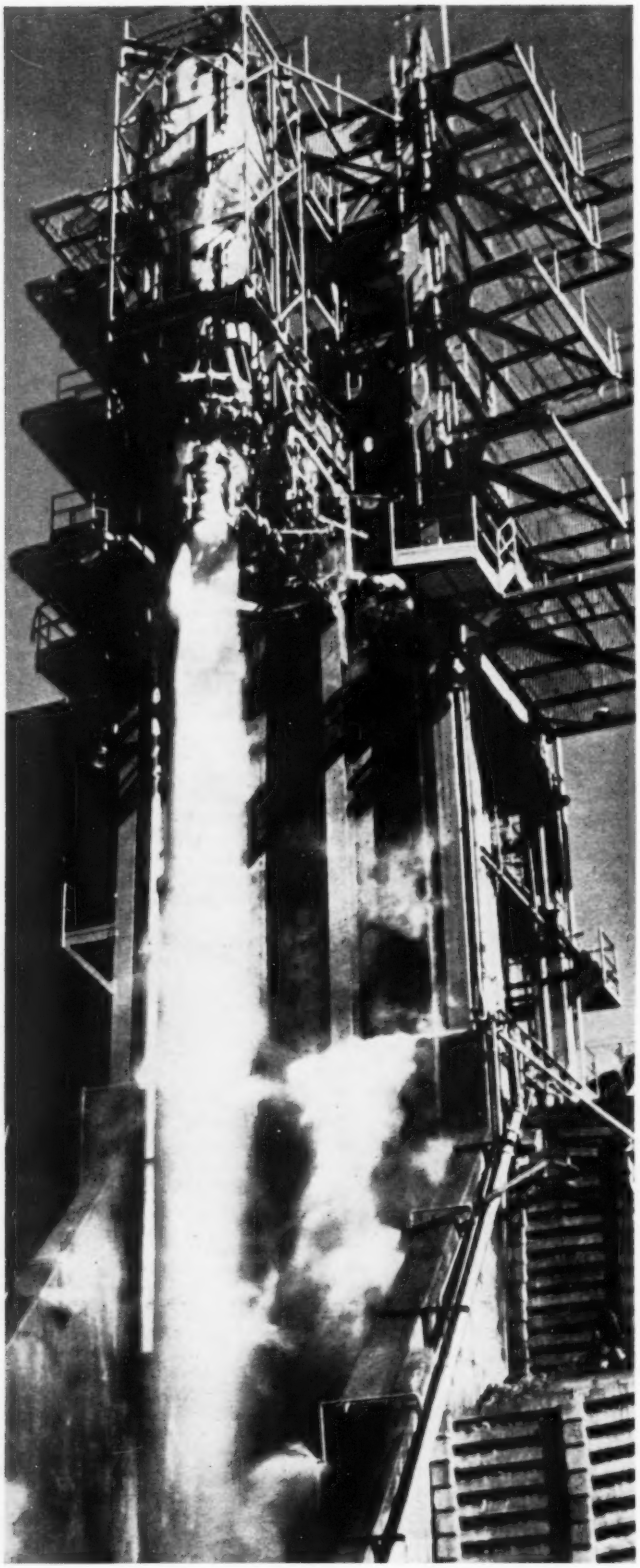
The Harvard School of Public Health will expand its research and teaching in the health hazards of nuclear radiation under a new grant from The Rockefeller Foundation, Dean J. C. Snyder announced recently.

The funds, in the amount of $500,000, will be made available from The Rockefeller Foundation over a 10-year period.

Currently, Dr. Snyder said, the School of Public Health is concerned with problems of radiation exposures to the public from nuclear power and from other applications of fissionable materials.

With the grant from The Rockefeller Foundation and through support from other financial sources, the School of Public Health will develop additional facilities for the instruction of physicians, engineers, and other public health specialists in the principles of radiological hygiene and safety.

OF CURRENT INTEREST



FIERY GASES stream from Redstone rocket engine as more than 75,000 pounds of thrust is delivered during static test.

Liquid Propellant Rocket Engine for Redstone

MORE THAN 75,000 pounds of thrust is developed by the liquid propellant rocket engine which has been put into production by Rocketdyne, a Division of North American Aviation, Inc., of Canoga Park, Calif., for the U.S. Army's midrange giant Redstone missile. This is a towering 62-foot rocket weapon measuring 6 feet in diameter.

That and other details of the engine—the first made available on a United States high-thrust rocket propulsion system—were released recently by the U.S. Army, which has incorporated the operational weapon into its arsenal.

Design Details

A rugged, single-chambered system designed and developed by Rocketdyne, the engine for the Redstone develops its thrust through the combustion of liquid oxygen and alcohol.

Designed by a team of scientists of the Army Ballistic Missile Agency and in production since 1952, the pioneering engine was advanced to its current performance level through many progressive design refinements.

The sixth model of this series of engines for the missile currently is being delivered to the Army and the Chrysler Corporation, manufacturers of the missile. This gigantic surface-to-surface weapon has been nicknamed "Sunday Punch."

Production Started

The first high-thrust (greater than 50,000 pounds) rocket engine to be placed in production in the United States, the Redstone system was designed for combat reliability and production by conventional manufacturing methods.

In early testing programs that began as early as 1950 at Rocketdyne's Propulsion Field Laboratory which is in the Santa Susana Mountains near Los Angeles, Calif., as many as 10 consecutive full-duration full-power runs were made with single-engine assemblies to prove rugged reliability before the system was placed in production.

Dimensions

Only 10 feet 11 inches long and 5 feet 10 inches in diameter, the latest model of the engine weighs less than 1,450 pounds.

Its liquid oxygen and alcohol propellants are pumped concurrently by the engine's 780-hp turbo-pump. A single turbine is driven by high velocity steam developed through the decomposition of hydrogen peroxide in a midget generator light enough to be held in one hand.

The engine withstands combustion temperatures greatly in excess of 5,000 F by circulating fuel between the thin double walls of its thrust chamber. The fuel passes through the chamber before being injected and

burned with liquid oxygen. Thoroughly tested before shipment from the Canoga Park manufacturing plant, the engine goes through another test firing after its long trip across country to Huntsville, Ala.

Pioneer Work

The development of the engine, which followed early work for the U.S. Air Force by a scientific team headed by world-famous Dr. Wernher von Braun, represented pioneering United States efforts in the production of large liquid-propellant rocket engines. Included in these efforts was the development of spare parts lists, maintenance and overhaul procedures, and crew training techniques.

According to the Army, this missile weapon is a high-accuracy, liquid-propelled, surface-to-surface instrument which is said to be capable of bringing tremendous fire power against enemy installations. Described as an important innovation for United States ground forces, it provides mobility, firepower, and range not possible with conventional artillery.

Project Personnel

Rocketdyne project engineer for the Redstone engine is W. R. Studhalter, a chemical engineering graduate of Texas Tech and the University of Michigan.

One of the first special field artillery missile battalions to be trained in the use of the Redstone surface-to-surface missile was the 217th Army Unit. The group was trained at the Army Ballistic Missile Agency, which is located in the Huntsville, Ala., area.

Versatile Operation

The inertial guidance and control system of the Redstone missile, which is entirely self-contained, enables it to follow a preplanned ballistic trajectory to the target independent of any outside influences. This system features special high-precision air-bearing gyroscopes designed and produced by the Ford Instrument Company, a Division of the Sperry Rand Corporation.

This system's program device receives all the necessary information concerning the flight path to be taken by the Redstone before launching. After the missile has been launched, the program device plays back signals to actuate the guidance system, thus controlling the missile as it travels to its precomputed target.

Additional Data

The shell for the fuselage of the missile is manufactured by the Reynolds Metals Company, Louisville, Ky. The overall prime contractor for the Redstone missile is the Chrysler Corporation.

In the City of New York, recently, one of the largest railroad treminal exhibits consisted of the giant Redstone guided missile. It was displayed in the main concourse of cavernous Grand Central Terminal. It was the largest single object ever to be shown there.

Amplifier Extends Range of Radio Telescopes

AN AMPLIFIER which may extend the range of radio telescopes 10 times farther out among the galaxies has been developed in the Gordon McKay Laboratory of Applied Science at Harvard University, Cambridge, Mass.

This device, which may enable man to "hear" the radiation from hydrogen clouds in galaxies beyond the range of any present instruments, was operated in a laboratory test for the first time the night of December 7, 1957. Scientists believe that the device will allow detection of signals one one-thousandth as strong as can be observed now.

Has Radar Uses

Its potential applications include certain radar systems as well as the research field of radio astronomy.

The "three-level solid-state maser" (for Microwave Amplification by Stimulated Emission of Radiation) was developed by a group of Harvard scientists: Dr. Nicholaas Bloembergen; Gordon McKay, professor of applied physics, who proposed the Harvard device in July 1956; Dr. J. O. Artman, research fellow in applied physics; and graduate student Sidney Shapiro.

Professor Thomas Gold, Harvard astronomer and authority on radio astronomy, stated that the Harvard College Observatory hopes, with the assistance of the Division of Engineering and Applied Physics, to apply the maser to the radio telescope as soon as possible. The job cannot be done immediately, he added, because of the extremely complicated and entirely experimental nature of this radio-telescope amplifier device.

To Test Cosmos Theories

Professor Gold predicted that the new device, once it is installed, would enable radio telescopes to reach out into the universe as far as or farther than the best optical instruments. A maser-equipped telescope should provide a test of cosmological theories (such as the theory of the expanding universe) "better than any other present means," he stated, and should be able to confirm or deny the existence of hydrogen gas between the galaxies, now only suspected.

The maser is an ingenious device which provides amplification by redistributing the magnetic moments of the electrons inside a crystal. The Harvard maser is not the first one, but it is the first to run successfully in the 21-cm (centimeter) wavelength band—the frequency of emission from interstellar hydrogen.

The term maser was coined in 1954 by Columbia University Prof. C. H. Townes who first proposed and then successfully constructed amplifiers of this type, using a gas instead of a crystal for an operating medium. Since that time, various gas masers have been built in several laboratories. The first operating solid-state maser of the type invented by Dr. Bloembergen was built at the Bell Telephone Laboratories in December 1956. Similar solid-state masers have also been successfully built at MIT's Lincoln Laboratory. However, none of these masers operated at 21 cm.

Catching Hydrogen Emission

Radio astronomy in the 21-cm waveband began at Harvard. The radiation from great clouds of hydrogen in outer

PERSONNEL at the Redstone Arsenal Army Ballistic Missile Agency, Huntsville, Ala., carefully remove Rocketdyne-made rocket engine for Redstone missile.

space—a steady signal produced by the "flipping" of electrons—was first recorded in 1951 by the Harvard physicists, Dr. H. I. Ewen and Prof. E. M. Purcell, Nobel laureate. The Harvard College Observatory initiated radio research on the hydrogen clouds in the Milky Way in 1953, with a 24-foot radio telescope. In 1956, a more powerful and sensitive 60-foot radio telescope began observations at Harvard's Agassiz Station.

Thumb-Sized Crystal

The heart of Harvard's maser is a single crystal of potassium cobalticyanide, with an intentionally introduced impurity of one half of one per cent of potassium chromicyanide. The crystal, about the size of the last joint of a man's thumb, is kept by a bath of liquid helium at 2 degrees Kelvin, a temperature only slightly above absolute zero.

Electrons of the impurity in three discrete energy levels are used. Amplification is gained by shifting electrons from level to level, within the crystal.

Electron Activity

In ordinary circumstances, when an electron falls from a higher level to a lower level, it gives off energy at a specific wavelength. When radiation of the same wavelength strikes an electron in the lower level, it kicks the electron back up.

In matter under normal conditions, each energy level has fewer electrons than the level below it. When radiation is applied, more electrons jump upward than downward, but a competing process, known as "relaxation" tends to return the system to equilibrium, sending the electrons back down. The time it takes for such downward jumps to restore equilibrium is known as the "relaxation time."

Amplifying the Signal

In the Harvard maser, an applied electromagnetic field pumps the electrons continuously from the lowest to the highest of the three energy levels. By keeping the crystal cold, the "relaxation time" is lengthened, and a maximum number of electrons is kept at the highest level. An incoming impulse of 21-cm radiation stimulates emission from the top energy level. Its electrons drop to the middle energy level, emitting 21-cm radiation. They give off far more radiation than the incoming trigger signal. The net effect is to amplify greatly the incoming signal.

The maser was developed with funds provided Harvard's Division of Engineering and Applied Physics under a contract which is with the U. S. Army, Navy, and Air Force.

Navy Talos Missile Makes Public Bow for Army

THE TALOS guided missile demonstrated publicly for the first time recently features a "traffic light" test system that tells when the weapon is ready for firing.

The Talos, manufactured by Bendix Aviation Corporation for the U. S. Navy and being evaluated by the U. S. Army for incorporation into the continental air defense system, uses the automatic test equipment designed and built by the York (Pa.) Division of the company to determine whether all of its systems are operating properly before it is launched.

The results are recorded by red and green lights, indicating which components have passed, or failed. A master green light on the system called Talos tactical test equipment (Tatte), will give the go-ahead, once all components have passed inspection. Bendix engineers have stated that this automated test equipment reduces the technical training requirements of military personnel assigned to the missile.

Land and Shipboard Use

A prototype installation called the "Desert Ship" was set up at the White Sands Proving Grounds, N. Mex., for testing the performance of the Talos with the automatic equipment, which is also designed for shipboard use.

Talos, a supersonic surface-to-air missile, was designed to provide the Navy with a system of long-range high-firepower defense against air attack. It uses an advanced version of the first ram-jet engine to be successfully flown in the United States.

Demonstration of the equipment in public, along with the actual firing of two missiles, was held in conjunction with the transfer of the land system from the Radio Corporation of America, which developed it in conjunction with the Navy, to the Army for evaluation.

Talos will form the major armament of the light cruiser *USS Galveston* now being converted to a guided missile cruiser. Plans are also being made to equip the first nuclear-powered cruiser with a Talos system.

Major Details

Talos is approximately 20 feet long, and 30 inches in diameter. It weighs about 3,000 pounds. The missile is accelerated to supersonic flight by a solid-fuel booster rocket about 10 feet long. The booster rocket is jettisoned when the missile reaches cruising speed.

At that time, the main ram-jet engine ignites and provides thrust to keep it at a constant speed throughout its flight. The engine develops 40,000 hp. Two stages of guidance give the Talos system the capability of high firepower as well as high accuracy at long range, Bendix engineers explain.

Fully Automatic

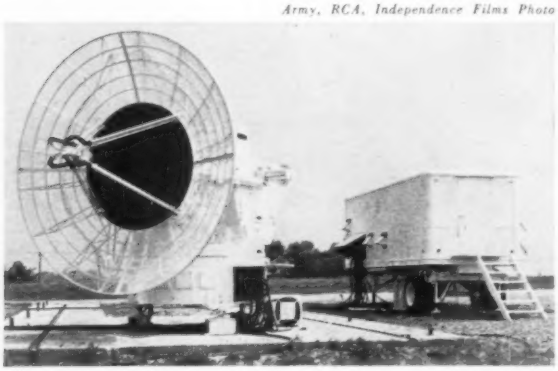
The installation from which the Talos missile was fired at White Sands, is the first fully automatic base ever devised for launching missiles and guiding them to their targets.

Designed and built by the Radio Cor-

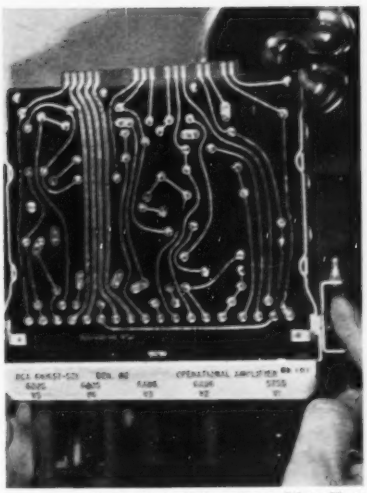
Army, RCA, Independence Films Photo

AUTOMATIC Talos launcher shown with a specially instrumented Talos missile. The missile remains on the cart while the launcher automatically slews and elevates to the proper position for firing, based on computed information indicating the target's position at intercept.

Army, RCA, Independence Films Photo



MODIFICATION of the precision instrumentation radar AN/FPS-16. Developed over a period of 10 years, this reliable, long-range radar provides a means for advanced operational features in the Talos defense unit.



Army, RCA, Independence Films Photo

REPLACEABLE, plug-in, printed circuit module.

poration of America under Government contract, the base is a complete electronic control center which can go into action by itself, in response to warning signals from distant outposts.

Without any human being touching a control button, the base computes the location of the attacking objects, their speed and course and the logical points of interception, then loads the missiles on the launchers and fires them automatically at the proper time and in the proper direction to bring down the attackers.

Each missile rides a guiding beam put out by the launching base until it reaches the vicinity of the target, whereupon a homing device in the missile itself senses the presence of the target and takes control of the course to zero in for the kill. One of the numerous advantages of the Talos defense unit is the fact it can fire single missiles or numerous missiles simultaneously at numerous targets, and can continue to fire over an extended period of time. Also, the Talos can carry either a high-explosive or nuclear warhead.

The control center, a one-story building about the size of a football field, with launching bases adjoining, was built by the RCA Missile and Surface Radar Department, Moorestown, N. J., and assembled at White Sands. It was turned over to the Navy October 15, 1957.

Land System

The Talos land-based system is an automatic defensive surface-to-air weapon system which has as its primary function the efficient protection of our military bases and industrial centers against air threats—both subsonic and supersonic. Three major factors contributing to efficient protection are coverage, rate of fire, and kill probability per missile salvo. The coverage range of Talos is sufficiently long so that each defense unit around a city or military base can participate in engaging a threat from any direction. This range, coupled with high- and low-altitude capabilities, gives Talos the greatest coverage of any local defense system in existence. Rate of fire is attained by using early warning information from radar networks for midcourse guidance and by time-sharing of major components of the system. This is referred to as multiplexing. High kill probability is assured by high over-all system accuracy and warhead lethality using either high explosive or nuclear warheads. In the design of the Talos defense unit extensive effort has been devoted to the application of human engineering techniques.

The Talos defense unit for the Army uses a Talos that is identical to the missile which was developed for use by the Navy and results in improved economy of the over-all Department of Defense program.

The basic design of the Talos system provides for the extension of capabilities with a minimum of modification to assure that the system will have continued effectiveness against present and future hostile threats.

Future Meetings of Other Societies

The Instrument Society of America

Chemical & Petroleum Industry Symposium, Feb 3-4, Hotel Du Pont, Wilmington, Del. ISA, c/o Taylor Instrument Co, 310 Industrial Trust Bldg, Wilmington, Del.

Pittsburgh Section, 8th Annual Iron and Steel Industry Conference, Mar 11-13, Roosevelt Hotel, Pittsburgh. F. K. Briggs, 361 Tampa Ave, Pittsburgh 34, Pa.

The Society of the Plastics Industry

Reinforced Plastics Division, 13th Annual Technical and Management Conference, Feb 4-6, Edgewater Beach Hotel, Chicago, Ill. G. L. Smead, Manager Reinforcement Sales, L-O-F Glass Fiber Co, Toledo, Ohio.

Canadian Section, 16th Annual Conference, Mar 6-7, Royal Connaught Hotel, Hamilton, Ont, Canada. L. P. Williams, SPI, 250 Park Ave, New York, N.Y.

ASQC, 2nd Annual Conference of Administrative Applications Division, Feb 7-8, Carter Hotel, Cleveland, Ohio. W. C. Lynam, B. F. Goodrich Chemical Co., 3135 Euclid Ave., Cleveland 15, Ohio.

ASTM, National Meeting, Feb 10-14, Hotel Statler, St. Louis, Mo. American Society for Testing Materials, 1916 Race St, Philadelphia 3, Pa.

NSPE, Spring Meeting, Feb 13-15, Michigan State University, East Lansing, Mich. K. E. Trombley, NSPE, 2029 K Street, NW, Washington 6, D.C.

American Institute of Mining, Metallurgical, and Petroleum Engineers

Annual Meeting, Feb 16-20, Hotels Statler and Sheraton-McAlpin, New York, N.Y. H. N. Appleton, AIME, 29 W 39th St, New York 18, N.Y.

Rocky Mountain Petroleum Sections, 4th Annual Joint Meeting, Mar 3-4, Cosmopolitan Hotel, Denver, Colo. H. N. Appleton, AIME, same.

Mid-Continent Local Section, Petroleum Production & Reservoir Engineering Conference, Mar 20-21, Mayo Hotel, Tulsa, Okla. H. N. Appleton, AIME, same.

National Wiring Conference, 14th Annual Meeting, Feb 20-21, Statler Hotel, Detroit, Mich. Frances Armin, National Wiring Bureau, 155 E. 44th St, New York 17, N. Y.

ASCE, Convention, Feb 24-28, Chicago, Ill. D. Reynolds, ASCE, 33 W 39th St, New York, N. Y.

Institute on Human Communications Seminar, Enlarging Managerial Capacity, Feb 24-28, Harvard Club, 27 W 44th St, New York, N.Y. William Exton, Jr, 101 W 57th St, Rm 1112, New York, N.Y.

Pennsylvania Electric Association, Engineering Section Winter Meeting, Electrical Equipment Committee, Feb 27-28, Hotel Roosevelt, Pittsburgh, Pa. R. W. Simmons, West Penn Power Company, Greensburg, Pa.

American Society of Mechanical Engineers

Gas Turbine Power Division, Conference and Exhibit, Mar 2-6, Shoreham Hotel, Washington, D.C. Barry Freer, 1500 Connecticut Ave, NW, Washington 6, D.C.

Aviation Division, Conference, Mar 17-20, Statler-Hilton Hotel, Dallas, Tex. L. S. Dennegar, ASME, 29 W 39th St, New York, N.Y.

Committee on Management, Conference, Mar 19-20, Somerset Hotel, Boston, Mass. L. S. Dennegar, ASME, same.

1958 British Electrical Conference, May 16-17, Palace Hotel, Brussels, Belgium. Sam Black, FIPR, 1958 British Electrical Conference, 36 Kingsway, London, WC2, England.

The Institution of Electrical Engineers, International Convention on Microwave Valves, May 19-23, Institution Building, Savoy Place, London W. C. 2, England. W. K. Brasher, IEE, same.

Extremely Fast Print-Out Equipment

DEVELOPMENT of the world's fastest print-out equipment, a device which will greatly accelerate the electronic processing and printing of computer data, was announced recently by Stromberg-Carlson, a Division of General Dynamics Corporation, and by The Haloid Company.

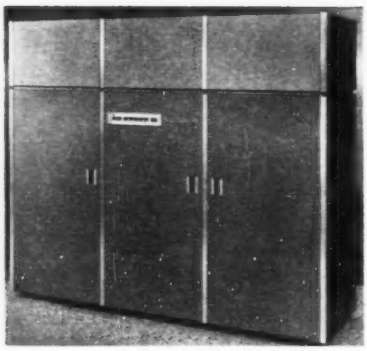
The product, Stromberg-Carlson Model *5000* high-speed electronic printer, was demonstrated at the New York Coliseum to representatives of the press and leaders of the computer industry.

It is an electronic unification of the unique CHARACTRON shaped beam tube of Stromberg-Carlson and The Haloid Company's XEROX COPYFLO printer. The resulting product is said to be the fastest commercially available device for high-speed printing of computer data. Furthermore, it achieves this speed without high-speed moving parts.

R. C. Tait, president of Stromberg-Carlson, and J. C. Wilson, president of The Haloid Company, in a joint statement said the *S-C 5000* will print the output of electronic computers at 4,680 lines (about 65 feet) per minute, 5 to 10 times faster than the speed of present electromechanical printers.

They said it is expected to have widespread use for commercial, scientific, and engineering applications in the field of data processing because of its output and the relatively low cost of operation compare with other printing devices.

H. P. Field, manager of the Stromberg-



Stromberg-Carlson, Haloid Photo

THE S-C 5000 High Speed Electronic Printer.

Carlson plant in San Diego, Calif., where the device was developed in a joint program with The Haloid Company, said the S-C 5000 can be used in both the on-line method of receiving electronic data direct from the computer, and the off-line method of receiving the data from magnetic tape.

The S-C 5000 will have such commercial data processing applications as preparing bank statements, billings, insurance notices, manufacturing control reports, missile and aircraft engine data reduction, address labels, etc.

In the S-C 5000, electrical impulses from the computer are translated into a display of numbers, letters, and symbols by means of the CHARACTRON shaped beam tube. Inside the tube, which is similar to a television picture tube, an electron gun shoots its beam through tiny shaped openings which form the beam into characters.

In the xerographic process, these characters are projected by an optical system onto the charged surface of a selenium-coated drum which is sensitive to light. The latent images thus produced are developed by cascading a pigmented powder over the surface of the drum and then printed on continuous rolls of paper. The XEROX printer is a modification of a standard Haloid product, the COPYFLO Model 1.

The smooth and quiet operation of the S-C 5000 permits its use in modern office areas.

A 7-inch CHARACTRON shaped beam tube which can display one million characters a minute is used in the S-C 5000. It reproduces 64 characters—the letters of the alphabet, 10 numbers, and 28 symbols, of the user's choice. Stromberg-Carlson also manufactures larger CHARACTRON shaped beam tubes for direct viewing and display applications.

The S-C 5000 will print out on rolls of paper, or on sheets cut to desired size by an electronically controlled cutter. Because the XEROX printer can be used with any kind of paper, the S-C 5000 will print on all grades of stock, from thin tissue to punched cards. This process is much less expensive than conventional methods requiring chemically treated paper. The machine also will print on vellum and offset masters.

Mr. Field said that in most applications of the S-C 5000 to commercial data processing, the off-line method probably will be most widely used. In some applications, an editing and control device will be supplied along with the printing device, he said. The editing and control instrument will provide a means of giving directions to the printing machine to control its operations, tailoring it to the individual requirements of any application.

The on-line method is expected to be used particularly in scientific and engineering processing. It produces answers in readable form immediately after complex problems are fed into the computer, by plotting curves and labeling them with alphanumeric and symbolic characters at the same time.

Both the CHARACTRON shaped beam tube and the XEROX COPYFLO printer are comparatively new developments in electronics and uniting them to form the world's fastest print-out device is expected to have a profound effect in the field of data processing.

New Radiation Exposure Limits Adopted

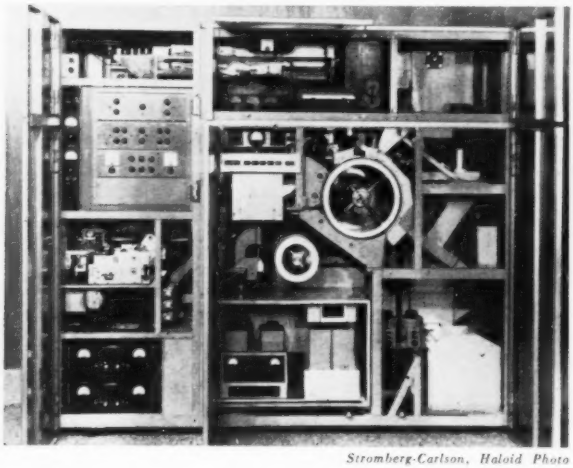
The AEC has approved for use in its facilities and those of its contractors new maximum permissible radiation exposures recommended by the National Committee on Radiation Protection and Measurement (NCRPM).

No appreciable modification of the AEC's present radiological safety practices will be required as a result of the new radiation exposure standards. In actual practice, the radiation exposure of nearly all of the workers in AEC facilities has been below both the new and the old levels recommended by the NCRPM. Such adjustments in present safety practices as are required will be made as soon as practicable.

The AEC action does not affect the operations of AEC licensees. Radiation exposure standards for licensees are set in an AEC regulation (Title 10, Chapter 1, Code of Federal Regulations, Part 20, Standards for Protection Against Radiation) which remains in effect. The AEC is currently considering amendments to this regulation to make it consistent with the new recommendations.

Most of the limits apply to occupational exposures received by workers in areas where radiation levels are monitored and controlled. A basic revision in the radiation standards recommended by the NCRPM is the inclusion of a new provision to limit the total radiation dose any individual may accumulate beyond the age of 18 to an average of 5 rems per year and not more than 15 rems in any year. (A rem, roentgen equivalent man, is a radiation dose of any ionizing radiation estimated to produce a biological effect equivalent to that produced by one roentgen of X rays.)

The NCRPM pointed out in connection with the new provision that "changes in



Stromberg-Carlson, Haloid Photo

HIGH-SPEED electronic printer, with cabinet open, to show S-C 5000 interior assembly.

Stromberg-Carlson, Haloid Photo

ALL PARTS of the S-C 5000 high-speed electronic printer are readily accessible for adjustment and servicing.

the accumulated maximum permissible dose are not the result of positive evidence of damage due to the use of earlier permissible dose levels, but rather are based on the desire to bring the maximum permissible dose into accord with the trends of scientific opinion."

Another basic revision in the NCRPM recommendations occurs in the permissible radiation levels for internal emitters, radioactive substances that tend to get into and remain in the human body. In controlled areas, the maximum permissible concentrations in air and water of radioactive substances that tend either to be distributed evenly throughout the body or to be concentrated near the gonads has been reduced to one-third of the values previously specified for occupational exposures to such radioactive substances.

For individuals outside of controlled areas, the maximum permissible concentration continues to be one-tenth of the recommended permissible exposures for radiation workers.

In addition to these occupational exposure limits, the NCRPM made the following recommendation regarding exposures to the whole population:

"The maximum permissible dose to the gonads for the population of the United States as a whole from all sources of radiation, including medical and other man-made sources, and background, shall not exceed 14 million rems per million of population over the period from conception up to age 30, and one-third that amount in each decade thereafter. Averaging should be done for the population group in which cross-breeding may be expected."

The AEC is in accord with the philosophy expressed in this recommendation. The AEC exercises control over the exposures resulting from its own operations and those of its licensees, but does not control exposures which the public may receive from other sources of ionizing radiation. Therefore, the AEC has adopted the requirement that its industrial operations must not release any radiation which might be expected to expose members of the populace to an average whole body dosage exceeding 0.5 rem per year or an average concentration of radioactive material exceeding one-tenth of the maximum permissible concentrations for occupational exposures.

This exposure limit for the public is in accord with a determination of the NCRPM that, if persons outside of controlled areas, but exposed to radiation from a controlled area, are assumed to receive yearly an average per capita dose of 0.5 rem, the total dose to the whole population from man-made radiations is not likely to exceed 10 million rems per million of population up to age 30.

Marine Corps Portable "TEW" Line

A new, highly portable, tactical early warning (TEW) system—which promises to extend radically the nation's tactical defense perimeters—has been developed for the U.S. Marine Corps by the Sperry Gyroscope Co., it was revealed recently.

The new long-range search and height-finding radar system will detect close-in or distant high-speed enemy aircraft and missiles. The lightweight system is designed to satisfy the Marines' particular requirement for helicopter transportable equipment, adaptable to changing tactical situations in any environment rapidly.

The new *AN/MPS-21* radar system—the first of comparable size and weight to provide three-dimensional data at extreme ranges—can be quickly transported by helicopter, cargo-type aircraft, truck, or amphibious vehicle. The system may be brought into operation in a battle area within a two-hour period. "This transportable 'TEW' system, which can detect enemy aircraft or missiles at altitudes and distances in excess of any presently existing or contemplated tactical system, is in keeping with the Marine Corps' tradition of hard-hitting mobility," a Marine Corps Headquarters spokesman said.

The spokesman revealed that Sperry's Surface Armament Division was awarded the contract by the U.S. Navy's Bureau of Ships to develop the new equipment. This research and development contract, one of the largest ever granted for such Marine Corps equipment, indicates its importance to the Marines.

The light-weight *MPS-21* system, using miniaturized components, is about one quarter the size and weight of conventional radar systems, yet has extended the detection range and accuracy to pick up missile-like supersonic targets at extreme distances. The equipment also is capable of highly accurate height determination to its maximum detection range. By incorporating detection and height determination, this equipment is capable of replacing two present radar systems.

The dome-like radar antenna shelter, designed by Birdair Structures, Inc., Buffalo, N.Y., resembles in appearance the permanent radomes used on the famous DEW line across the far reaches of the North American continent.

The lightweight transportable *MPS-21* system, however, uses an inflatable, dual wall, air-mattress-like radome. It, like the system itself, is designed for use in climates ranging from the tropics to the arctics; the radome is cooled or heated as needed.

A compact "V-beam" antenna, developed for the system by Sperry's Microwave Electronics Division, enables the *MPS-21* operators to redetermine the range, azimuth, and altitude of all enemy targets once every 10 seconds.

U.S. Marine Corps, Sperry Gyroscope Photo

SCALE MODEL of the U.S. Marine Corps' TEW system antenna demonstrates how compact V-beam paraboloid-shaped antenna can be assembled building-block fashion.

In the field, the component parts of the system are transported on self-contained "pallets." After a site is selected, the V-beam antenna system, the generators, the combat interceptor control shelter, and the inflatable radome can be erected by an 18-man crew. Within a two-hour period, the virtually automatic system can be in operation.

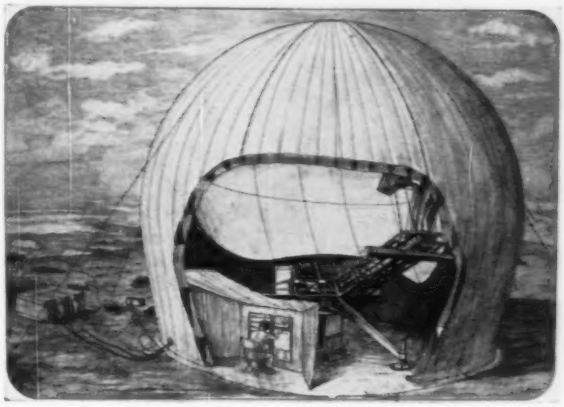
Signals picked up by the rotating antenna are passed down to the radar control console in the radome. From this console the signals are fed to the combat interceptor control shelter nearby where range azimuth and altitude information is presented on plan-position indicators and counters. Normally, only one operator would be located in the radome to monitor the radar.

The *MPS-21* system will have a very high peak transmitter power, thus enabling it to achieve its extreme range.

The system uses a compact V-beam antenna. Sperry Engineers, by using special molding techniques, have succeeded in superimposing search and height-find radar paraboloidal-shaped "dishes," into a single antenna. The face of each reflector is energized in such a manner as to produce a composite, simultaneously transmitted radar beam, consisting of a vertical beam for search and slant beam for height-finding. Each surface of the V beam antenna is fed by a separate horn; two additional horns are used to receive.

As the antenna rotates, an automatic computer determines the height and

U.S. Marine Corps, Sperry Gyroscope Photo



TEW SYSTEM is shown in artist's concept of the inflatable radome which can be heated or cooled as needed, depending on the location of the Marine Corps station or the season.

range of enemy targets by measuring return echoes picked up by the vertical and slant beam reflectors in relationship to the angle between the two and the time between echo "hits" on them.

Laminated Bits To Gather Satellite Weather Information

Four pieces of laminated plastic, each smaller than a dime, meet severe weight, temperature, and dimensional stability requirements when used as insulating spacers in an earth satellite instrument that will measure radiation reflected by the earth's cloud layer.

Part of an experiment planned by the Signal Corps Engineering Laboratories, this instrument, which is known as the "Weather-Eye," will help meteorologists gather information about clouds for weather study and prognostication. Because present long-range weather forecasts are based on information covering only 5% of the earth's surface—the additional data that will be gathered on cloud patterns, thickness, types, and moisture content will become key clues to forthcoming weather.

The optical system that will gather this data was developed by Perkin-Elmer Corp. (P-E), Norwalk, Conn. Two of the units, each hardly larger than a pack of cigarettes and weighing less than 4 ounces, will be mounted in the satellite and will peer through holes in its shell at the cloud layer. One will look forward, the other backward.

In construction, each weather-eye utilizes an f 0.7 mirror only 3 inches in diameter by 3/16 inch thick. Infrared cloud radiation will be picked up by this mirror and focused on a tiny detector unit 1/25 inch long by 1/25 inch wide. This detector unit is cemented into place over the center hole in the laminated plastic printed circuit material.

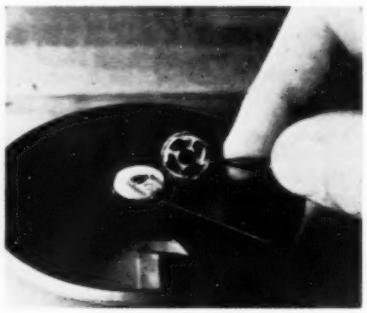
Another piece of laminated plastic has a silicon solar battery system soldered to it. These batteries provide signals to distinguish between day and night and turn off the equipment when the satellite is on the dark side of the earth. Two other similar laminated plastic insulating spacers are also used in this unit.

DIME-SIZE piece of printed circuit material holds sensing device that measures radiation reflected from the earth's cloud layer.

P-E had several requirements for the laminated plastic printed circuit material that was to be used in this equipment. They were: (1) dimensional stability, (2) light weight, and (3) ability to withstand a wide range of operating temperatures. P-E selected Phenolite grade *G-10-865*. This material, a continuous filament-type glass cloth bonded with an epoxy resin, is made by National Vulcanized Fibre Co., Wilmington, Del.

In addition to meeting the qualities demanded for this application, the *G-10-865* also features good dielectric strength, low water absorption and dissipation factor, and excellent bond strength. It is used primarily where high insulation resistance and dimensional stability are a requisite. For this reason it is excellent for printed circuits.

In addition to the P-E optical system, the complete Weather-Eye system in the earth satellite will consist of an amplifier, tape recorder, telemetering circuit, and control circuitry. These components have been developed by the U. S. Army Signal Corps Engineering Laboratories, which have the over-all responsibility for this experiment.



PHENOLITE, pinched in tweezers, holds a silicon solar battery system—the four black objects around the center circle that is part of the detector system. These batteries provide a signal to distinguish between day and night and turn off the equipment when the satellite is on the dark side of the Earth.

Developments of U.S. Army Revealed

Signal Corps and Radio Amateurs Symposiums. The First U. S. Army Military Affiliate Radio System (MARS) Technical Net began official operation early in January 1958 with the first of a series of technical symposiums for amateur radio operators. The net operated on a single sideband (upper sideband) on 4030 kilocycles and will operate each Monday evening at 9 p.m. (EST).

The Army MARS network is a secondary means of communication for the Army in the event of a national emergency or disaster. Members are amateur radio operators from all parts of the United States as well as official Army Signal Corps stations. The technical symposiums will be conducted after members report into the net.

Ed Piller (A2KPQ), of Whitestone, L. I., N. Y., who is technical director of the net, said that because of the frequency and time transmission range should be up to 700 miles, which is sufficient to cover the First U. S. Army area.

The net control station will be operated by Al Bein (AA2BWQ), of Clifton, N. J. Key stations operating from each of the larger cities in the First U. S. Army area are being planned. The system will permit selection of a wide range of speakers from some of the leading electronic laboratories in the northeastern section of the country.

Membership in the net is open to any active radio amateur in New York, New Jersey, or any of the New England States. Information on membership can be obtained from Herbert Huffan, MARS Director, First U. S. Army, Governors Island, New York 4, N. Y.

High-Altitude Weather Conditions. Development of an "electronic weatherman," a wizard at figuring vital high-altitude weather conditions, has been announced by the Department of the Army.

The new system spots high-altitude indications of oncoming storms, hurricanes, tornadoes, and other bad weather far faster and more accurately than any previous device. It is the first system able to chart high velocity winds like the jet stream on a routine basis.

Developed by the U. S. Army Signal Engineering Laboratories, Fort Monmouth, N. J., the system reduces long, difficult calculations now required to interpret data from a weather balloon flight. It tracks the balloon and a built-in electronic "brain" does the figuring instantly.

Winds and weather high above the clouds affect ground conditions and inaccurate or delayed balloon reports could cause false weather predictions. In battle, knowledge of shifting upper atmosphere winds is vital in aiming long-range artillery and missiles accurately.

Civil defense and military leaders also need such wind data to predict radioactive dust cloud drift after a nuclear blast. With this data, airlines might possibly plan cross-country flights to take full advantage of the jet stream as a high-velocity tail wind.

The system tracks balloons to an altitude of 24 miles or higher with its radar-like antenna and follows the balloons' radio signals automatically. It tracks precisely, even if there is a 200 miles drift from the launching site—twice the effective range of previous equipment. For tactical operations, the set may be carried in a van and can be set up for operation in three hours.

The system, first of its kind with a "brain," was developed by the Laboratories' Meteorological Branch. It is designed to replace its predecessor eventually, the computerless *AN-GMD-1*, now standard equipment in the military services and widely used by the U. S. Weather Bureau.

Fog Particles Counted. A device to count and measure fog particles has been developed at the Army Chemical Corps' Chemical Warfare Laboratories, Army Chemical Center, Maryland.

Expected to prove highly useful in

studies of chemical fogs and other fine particle matter, the new device also is believed to have possible industrial uses. It is portable, electronically operated, and semiautomatic.

With this counter, one man can measure and record, with one hand, at an average rate of 3,300 particles per hour—as compared with 1,250 particles per hour for the old method. In addition, the operator can work a full 8-hour day without undue fatigue. Using electronic calipers, the operator measures greatly magnified particle images flashed on a screen, and presses a foot pedal. This sends an electrical message to a series of small meters (like mileage indicators on cars) which record the number of each size counted.

It is expected that this counter will replace the tedious method, now in use, requiring two men—one measuring and the other recording.

The counter was invented by Martin Memolo, an engineer at the Chemical Warfare Labs. He stated that although there were completely automatic counters of higher performance, one of the objections to them for Army Chemical Corps use was that they could not distinguish between droplets of moisture and other kinds of particles.

Missile Master System Put into Operation. Missile Master, the first fully operational electronic air defense control system in the United States, was put into action recently by the Army Air Defense Command.

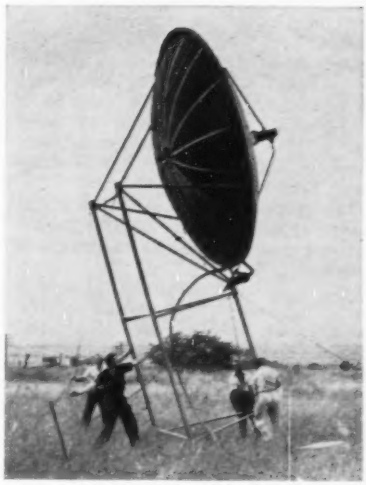
Located at Fort George G. Meade, Md., missile master will help defend the Washington–Baltimore Government–industry complex against air attack. It is an electronic system which controls and coordinates the fire of the Armys' air defense weapons to insure their maximum effectiveness. Targets can be selected economically, with control of each NIKE missile being retained by local battery commanders. In this way, preselected targets in an attacking air fleet are assigned for destruction by Missile Master to individual batteries of a NIKE network.

This first Missile Master installation is operated by the 35th Antiaircraft Artillery Brigade. The Army said that the next Missile Master systems to become operational will be for the New York, N.Y., defense area and other strategic, industrial, and population centers across the nation.

Missile Master electronically stores all information on targets in the area and presents it on a television-like picture tube in a simplified form. This is in addition to its instantaneous transmission function.

Air-Transportable Radio Terminal. A compact, air-transportable radio communication terminal with an antenna that inflates like a balloon, is now being evaluated at the U. S. Army Electronic Proving Grounds, Fort Huachuca, Ariz. The terminal was designed and built for the U. S. Army Signal Corps by Collins Radio Company, Cedar Rapids, Iowa.

Capable of being completely packed in two metal "huts" that serve as shelters when the station is erected, this terminal is said to provide the greatest mobility available today for radio communication called "Transhorizon." This mobility improves the effectiveness of fast-moving Army tactical units needing communication to points beyond the horizon.



U.S. Army Photograph

AIR-INFLATED antenna is easily erected or dismantled at station site by only a few men. Tower and folded fabric can be stored in a space 3 by 2 by 7½ feet.

The two huts are carried by such transport aircraft as the *C-119* "Flying Boxcar" or the *C-124* "Globemaster," and by motor vehicles.

The Transhorizon method, based on the scattering effect of radio waves, provides extremely reliable radio communication for ranges of 50 to 150 miles without intermediate relays. Up to 12 voice or 96 teletypewriter messages or any combination of these can be transmitted or received simultaneously at the single station. It operates in the ultrahigh-frequency range, just above that currently used for most television channels.

Two dish-shaped antennas 15 feet in diameter are utilized. The inflatable portion of the antenna consists of two pieces of plastic fabric clamped together at a hoop-shaped girder to form an enclosed envelope. The rear piece of fabric is coated with aluminum to reflect the radio energy.

A motor-driven blower inflates the antenna to the desired pressure in about 12 minutes and then maintains this pressure. The inflated antenna is designed to withstand winds up to 70 miles an hour without destruction of the desired shape of the antenna, and it has, in fact, easily weathered 50-mile-an-hour winds at the test site.

Electronic Device Aids Delicate Eye Operation

An electronic weapon in the fight against blindness was announced recently by Dr. Charles Burrows, vice president for engineering, Ford Instrument Company. The device assists surgeons in the delicate operation of reattaching retinas.

Detachment of the retina, the innermost coat of light-sensitive cells located in the back part of the eye, can be caused by a blow on the head or other common injury. Retinal detachment rivals the cataract as a cause of blindness.

Electronic engineers of Ford Instrument, Division of Sperry Rand, worked closely with doctors of the New York Hospital–Cornell Medical Center to develop the device called an Ophthalmo-Electrotome. Dr. Burrows said his company believes in the development of electrosurgical control equipment to put the latest electronic engineering know-how to work in the operating room.

Unlike conventional electrosurgical equipment, the Ford device enables the surgeon to control both voltage and frequency and thus prevent burning delicate tissues. This instrument is now being used on research animals at the New York Hospital–Cornell Medical Center.

Ford Instrument pioneered in development of weapon controls for the military and currently builds the guidance controls for the Army's Redstone and Jupiter missiles. "We are just as proud of our medical 'weapon' as we are of our military weapons," Dr. Burrows said.

AEC and UN Atomic Energy Developments

Peaceful Uses of Atomic Energy. Secretary-General Dag Hammarskjold has announced the appointment of Professor S. A. Eklund, director of research of the Swedish Atomic Energy Company, Stockholm, as Conference Secretary-General of the second International Conference on the Peaceful Uses of Atomic Energy, which will be held under United Nations (UN) auspices in Geneva, Switzerland, September 1-13, 1958.

Professor Eklund is expected to arrive in New York toward the end of October and will serve as an officer of the UN Secretariat.

The provisional agenda provides for a series of general sessions on subjects including the possibility of developing thermonuclear power (by fusion instead of fission), experience with nuclear power plants, the future of nuclear power, use of nuclear energy for purposes other than production of electricity (for example, ship propulsion), progress in the use of radioactive isotopes, and health aspects of nuclear power programs.

Titles and abstracts of papers to be presented at the Conference are to be submitted by March 1, 1958, and the full texts by June 1, 1958.

U.S. Participation in Geneva Conference. Preliminary plans for United States participation in the Second International Conference on the Peaceful Uses of Atomic Energy, at Geneva, Switzerland, were announced by AEC Chairman Strauss.

The UN, noting the impressive results achieved at the 1955 International Conference, passed a resolution on December 3, 1955, calling for a second conference for the exchange of technical information to be held under UN auspices.

The U.S. Government has accepted the invitation to participate in the Conference which was extended by the Secre-

tary-General of the UN to Member States of the UN and its specialized agencies.

The United States will present at the Conference, technical papers, films, and exhibits describing progress in the peaceful uses of atomic energy. Invitations to prepare technical papers have been extended to United States scientists and engineers through approximately 4,000 universities, laboratories, industrial firms, hospitals, and AEC contractors.

New AEC Headquarters. The new headquarters building of the Atomic Energy Commission (AEC) near Germantown, Md., was dedicated on November 8, and relocation took place in January.

President Eisenhower delivered the dedicatory remarks during the ceremony, and L. L. Strauss, AEC chairman presided.

President Eisenhower unveiled a replica of the building's dedication plaque by pressing a button setting in motion a device powered by storage batteries charged by nine of the nation's developmental power producing reactors. These are the Naval Reactor Facility, formerly the land-based prototype of the *U. S. S. Nautilus;* the Boiling Reactor Experiments (BORAX); the Developmental Boiling Water Reactor of the General Electric Company, the first private power reactor to be AEC licensed; the reactor powering the nation's first atomic submarine, the *Nautilus;* the Army Package Power Reactor (APPR-1); the Sodium Reactor Experiment (SRE); the Experimental Boiling Water Reactor (EBWR) and the reactors powering the *U. S. S. Seawolf* and the *U. S. S. Skate*, second and third in the line of atomic submarines.

Export Research Reactor to Italy. The AEC has given notice of proposed issuance of a license to the American Machine & Foundry Company, New York, N. Y., for export of a research reactor to Italy.

The company plans to ship a 1,000-kw, pool-type reactor, light-water cooled and moderated, to the Societa Richerche Impianti Nucleari in Milan, Italy. The total value of the shipment is stated to be $489,000.

Proposed issuance of the license is based on AEC determination that it is within the scope of and consistent with the agreement for co-operation between the Governments of the United States and Italy.

AEC Issues Martin Experimental Facility License. The AEC has filed notice of proposed issuance of a license to The Martin Company, Baltimore, Md., for operation of a nuclear experiment facility at Middle River, Md.

A permit for construction of a facility having two critical experiment cells operating independently of each other was issued on May 13, 1957. The proposed license will authorize conduct of experiments relating to the Martin Power Reactor (MPR). The facility will be operated at near zero power. Maximum power will not exceed 10 watts.

The reactor type to be investigated is a heterogeneous, water-moderated pressurized system using stainless steel clad enriched tubular fuel elements. The critical assembly will be a prototype of the core of the MPR and will be used to check theoretical calculations and predict the nuclear characteristics of the reactor.

Large-Scale Homogeneous Nuclear Power Plant. A proposal for construction of a nuclear power plant utilizing a homogeneous type of reactor has been filed with the AEC by the Pennsylvania Power & Light Company and Westinghouse Electric Corporation.

The proposed plant would have a generating capacity of from 70,000 to 150,000 kws and would operate on the thorium–uranium cycle.

The aqueous homogenous concept is one of the basic designs regarded by AEC as ultimately having commercial possibilities. The two organizations to date have invested $5.5 million in the development of the single-region type of aqueous homogeneous reactor and created a fully staffed, $2-million research facility where work is being carried out. Recently the Baltimore Gas & Electric Company also joined the homogeneous reactor project group.

The proposal asks the AEC to make uranium fuel available and to waive the charges on its use. Also, to extend certain other forms of assistance including waiver of charges on the use of heavy water. These waivers of charges are asked for the first five years of plant operation. The present estimated capital cost for a plant of 150,000-kw capacity is $57 million, or $380 per kw, which is substantially more than the cost of a conventional power plant.

The proposal submitted to the AEC specifies that the companies will repay any amounts advanced by AEC for research and development during the 1958-1959 initial step should the companies alone determine, for reasons other than technical infeasibility, that further pursuit of the project is unwarranted.

This is the only nuclear power project in the United States dealing with a single-region slurry reactor system based on the thorium–uranium cycle. The homogeneous reactor type involves, among other things, new problems of remote maintenance because of the fluid fuel that is used. This reactor type also has important advantages which make its development worthwhile, including a potentially low fuel cost due to a high breeding ratio and the use of relatively inexpensive thorium as fuel, as well as uranium, and the reactor's inherently good safety characteristics.

12.5 Billion Electron Volt Accelerator. The AEC has authorized a 12.5 billion electron volt proton accelerator to be built at the Argonne National Laboratory, Lemont, Ill. The total cost of construction of the accelerator is estimated at $27 million, and $1.5 million has been made available initially for detailed design work.

High-energy particle accelerators are important tools for basic research, and have greatly advanced knowledge of nuclear structure and reactions.

The new Argonne machine will produce greater numbers of accelerated particles than any other of the multibillion electron volt accelerators now in operation or under construction anywhere in the world.

The Soviet Union has reported that it has a 10 bev accelerator in operation.

The 12.5-bev accelerator to be built at Argonne will provide a valuable tool for high energy physicists at a Midwest location. It is expected to be in operation in about four or five years.

Public Hearing on NACA Permit. J. A. Kyle, hearing examiner designated to conduct a public hearing and render an initial decision in the matter of an application by the National Advisory Committee for Aeronautics (NACA) for a permit to construct a testing reactor near Sandusky, Ohio, issued the following order fixing the date and place of the hearing:

> IT IS ORDERED, This 6th day of December, 1957, with the concurrence of counsel for all parties, that the hearing herein will commence on January 16, 1958, at 10 o'clock A.M., in Hearing Room C, Interstate Commerce Commission Building, 12th and Constitution Avenue, N. W., Washington, D. C.; and
>
> IT IS FURTHER ORDERED, that all parties seeking intervention in this proceeding pursuant to Section 2.705 of the Commission's Rules shall file their petitions to intervene with the Secretary of the Commission on or before January 10, 1958.

The order was published in the Federal Register issue of December 12, 1957. In an earlier Federal Register notice (September 7, 1957) the AEC specified the issues to be considered, and on December 5, 1957, notice was published that a report of the Advisory Committee on Reactor Safeguards is available for public inspection in the AEC's Public Document Room at 1717 H Street, N. W., Washington, D. C. An analysis of the safety aspects of the reactor prepared by the staff of the Division of Civilian Application is also available in the Document Room.

EBR I Restarted with New Core. The nuclear reactor that produced the world's first electricity from atomic energy has been restarted, and is undergoing preliminary tests prior to operating at power again.

Experimental Breeder Reactor I (EBR I) of the AEC achieved criticality after the installation of a new core, called Mark III.

After the successful completion of test operation and the achievement of full power the reactor will be used to investigate the effects of mechanical, hydraulic, thermal, and nuclear variants on the stability of fast reactors. The Argonne National Laboratory, Idaho Division, National Reactor Testing Station, near Idaho Falls, Idaho, was the site of the reloading.

The reloading of EBR I with the new Mark III core climaxes two years of research and design work, leading to a core which is expected to perform with greater stability than previous EBR I cores. The achievement of criticality with the new core on November 11, 1957, marks the first time the historic reactor has operated since November 29, 1955.

Computers and Basic Research

One of the hopeful ways of speeding man's search for knowledge about himself and his environment is to apply electronic digital computers to basic research in a university setting, it was asserted in a progress report made by the Computer Center at the University of Pennsylvania.

The Computer Center at the University was built around a gift of a $1.44 million Univac system from the Sperry Rand Corporation.

It was said, at the dedication ceremonies, that this Center would be devoted more fully to basic—as contrasted with applied—research than any previous computer installation. This research ranges from "what makes people buy what things to a new plan for correlating the paperwork of the building industry."

How much we buy of what, and why, is the subject of a Computer Center project being run by the University's Wharton School of Finance and Commerce.

It is felt that such basic knowledge will be of assistance in predicting total American consumption and in isolating precisely what things determine patterns of individual buying.

Dr. Yu H. Ku, former vice minister of education in pre-Communist China and now a professor in the Moore School of Electrical Engineering at the University, is directing a project looking toward more efficient and automatic operation of mechanical and electrical systems.

Univac, by programming the mathematics of studies on the response of nonlinear control systems, is contributing to the better performance of such mechanisms as torpedoes and aircraft.

Dr. Ku's studies are being watched with interest, it was said, by members of the International Union of Theoretical and Applied Mechanics. He was one of 15 members selected for the general assembly of the Union for the years 1946 to 1960.

In the medical field, the energy source or motor of a human cell and how it works is being analyzed through a School of Medicine project at the Center, which is directed by Dr. Britton Chance, director of the Johnson Foundation and professor of biophysics at the school.

The behavior of framed structures—such as bridges and buildings of any shape—is under study at the Center by Sidney Shore, associate professor of civil engineering, and colleagues. Here, Univac is solving mathematical equations describing the response of structures; i.e., the deflections and forces to which a structure is subjected.

Providing civil engineers with the ability to analyze and design larger, more complex three-dimensional structures with greater accuracy and efficiency is one specific goal of Mr. Shore's group.

Another Wharton School project at the Center finds the Univac not doing mathematics at all, but manipulating business data for information now unobtainable in most offices.

A joint effort involving Wharton faculty members Adrian McDonough, Leonard Garrett, and Paul Anderson with the aid of students in a computing class, this project is designed to solve the mailing list problems besetting businesses and organizations.

Data on cards is fed into Univac's electronic tapes: names, addresses, date of subscription, class designation. At any time, changes for any individual can be up-dated directly onto the tapes. The correct data can then be run off onto cards or envelopes via tape to card converter or the high-speed printer, which are parts of the computer installation.

Finally, Preston Andrade, lecturer in architectural design at the University's School of Fine Arts, is readying a project to relieve the human brains of the building industry from the load of current clerical operations.

Present building practices call for the use of hundreds of standard or prefabricated units, as well as thousands of specially designed pieces—all to be fitted into minimum spaces. Choosing precisely the right kind of beam or window from this selection is a painstaking process today. The designer cannot possibly explore all the combinations available.

Mr. Andrade proposes ultimately to feed into Univac all the variables which make up any building. With the computer's skill at analyzing thousands of combinations, the designer, engineer, or subcontractor could make a single correct choice almost at once.

The resulting speed-up of routine planning, design, and estimating would liberate the human brains of the industry for more creative thinking on planning, design, and construction. Much greater economy and freedom of design are expected to follow.

Bill Changer for Vending Machines

The first practical robot cashier which will accept a dollar bill and make change automatically has been unveiled by a Chicago, Ill., scientist.

Called the Bill Changer, the new device will create a long-predicted revolution in the vending machine industry, according to its inventor, W. A. Patzer, president of the A. B. T. Manufacturing Corporation, Chicago, subsidiary of Atwood Vacuum Machine Company, Rockford, Ill.

The Bill Changer will go into production and will be available soon. Simple, rugged, compact, inexpensive, and foolproof, the Bill Changer will usher in a new era in consumer automation, it was predicted.

Operating on electronic principles, the Bill Changer accepts a $1 bill, checks it, and in just three seconds returns two quarters, three dimes, and four nickels. The machine could easily be adapted to dispense other change to fit specific needs—from two half-dollars to 100 pennies. It also could be modified to accept currency of other denominations—$2, $5, or $10 bills.

The robot cashier will accept wrinkled or crumpled money, creased bills, grease-stained bills, torn money that still is good, bills that have been written or scribbled on, and bills inserted upside down or reversed. The $1 Bill Changer will reject bills of larger denomination, foreign currency, and fake money of all kinds. The device will detect and reject bad bills at least as well as a human cashier, according to Patzer. It will also reject two valid $1 bills accidentally placed in the machine together.

In addition to returning a dollar's worth of coins for a dollar bill, Bill Changer can be adapted to dispense any item of merchandise plus the proper change.

Although the vending machine industry has long recognized the tremendous potential value of a machine which would accept currency, attempts to solve the technical problems have been uniformly unsuccessful. Much of the work of the past has been along the lines of photoelectric scanning devices.

Reservations Made in Seconds

Automation took another great stride forward today, as Sheraton Corporation of America, at the start of the 42d National Hotel Exposition, unveiled the hotel industry's first automatic electronic reservations service.

The electronic data processing system, designed and built by Teleregister Corporation, Stamford, Conn., enables clerks in three New York City hotels to determine almost instantly what accommodations are available in 16 Sheraton hotels from coast to coast.

The new service, which the hotel chain calls RESERVATRON, initially was put into operation at the Sheraton-Astor, Sheraton-McAlpin, and Park Sheraton in New York, N. Y. It is expected that by early 1958 all 45 Sheraton hotels in the United States and Canada will be included in the system.

According to Pres. Ernest Henderson, who demonstrated the new system at the Sheraton-McAlpin, RESERVATRON makes all other hotel reservations systems obsolete. It is estimated that by 1959, it will permit this hotel chain to handle with ease more than half a million reservations a year—almost twice the present load with the manual teletypewriter system.

Mr. Henderson indicated that in the 13 years since his company first introduced free teletypewriter service to hotels, reservations traffic has multiplied to such an extent as to strain present communications facilities to their capacities.

The RESERVATRON was described as similar to the automatic reservations systems currently employed by major airlines by Teleregister Pres. S. J. Sindeband. He said that the nerve center of RESERVATRON is an electronic "memory drum," located in Teleregister's Service Bureau in New York City, which retains up-to-the-minute information about every Sheraton guest room. A clerk seeking to fill a reservation request for any hotel in the system merely inserts a special plate into a "keyset," flick of a switch and the system extracts the requested information from the "memory drum" and reports back what rooms are available in four different categories on the date the customer plans to arrive and for the following three days as well. The

system stores all such availability information for 31 days ahead.

Harmonic Drive Principle Demonstrated

Among new devices displayed at the recent AtomFair were examples of the "harmonic drive" principle developed by the Atomic Power Department of the United Shoe Machinery Corporation, (USM) Beverly, Mass. Although not yet fully proved or in commercial use, the principle offers extremely interesting possibilities, particularly in the atomic power field, according to USM officials.

Harmonic drive makes use of controlled waves of deflection to produce powerful rotary or linear forces. Deflection waves are produced in solid steel walls of vessels, pipes, or other enclosures, in order to drive mechanisms within those walls. The principle eliminates the need for valve stems or other parts passing through the wall. A valve, for instance, can truly be hermetically sealed.

The principle of harmonic drive was illustrated by means of a linear actuator which demonstrates application of the principle to a control rod drive mechanism. Two harmonic drive valves also on display, included one of plastic to show visually the principles of the valve's operation.

Using the harmonic drive principle of motion transmission, an hermetically sealed valve can be made with all rotating parts outside the valve. Sealed within the valve are only two moving parts, which are valve closure segments. Movement and control of these parts by the external motor drive is through surfaces in almost pure rolling contact.

Positive position indication is accomplished by a direct precise mechanical connection. The valve closes to a preset torque level.

The characteristics of this valve are given as 6-inch ID, design pressure of 500 psi, 450 F temperature (motor limitation 200 F), linear operating speed 25 inches per minute, 8 seconds operating time, 98% rolling contact, 0.2 motor hp, 250 watts (110 volts, 60 cycles, single phase), with all parts fully enclosed and controlled closing torque.

An hermetically sealed means of controlling nuclear reactors is available too, using the harmonic drive principle of motion transmission. All rotating parts are placed on the exterior of the pressure vessel and there is only one interior moving part. Thus, the driving surfaces are in virtual rolling contact. In order to ensure positive position indication, a mechanical indicator, at all times, is directly connected and responsive to the control rod position. This mechanism can be driven by any conventional power source. It has a normal operating pressure of 2,200 psi, normal operating temperature of 565 F, hydrostatic test pressure of 3,750 psi, maximum operating temperature of 650 F, 20 inches per minute for linear speed of control rod, 30-inch length of travel, 2.66 square inches of projected-tooth contact area, 1,195 psi maximum thread contact stress at 100-pounds load, 74,400 pounds maximum permissible load at 70 F, 67,200 pounds maximum permissible load at 650 F, 97.5% rolling contact, and 0.5 motor hp.

Nebraska Pioneers Electronic Vehicle Control

Improvements in road engineering and automobile construction are steadily diminishing demands on the human driver and reducing hazards resulting from mechanical failure. Accident hazards, however, are increasing with the frequent long-distance driving on modern turnpikes, where the driver has to do little more than maintain a fixed speed on a fixed course.

These considerations, together with the periodic hazards of poor visibility in fog, smog, storm, or darkness, several years ago led to considerations of possible ways in which electronics might relieve the driver of his semiautomatic function and, thus, minimize the human factor in the cause of accidents. The technical feasibility of the idea was demonstrated by several automatic driving system features incorporated in a miniature model installation. In the model, as in any full-scale realization of the idea, electronic control demanded modifications both in the roadway and in the vehicle.

However, any automatic driving system had to be compatible with present-day conditions, inasmuch as it could be introduced successfully only if it could be introduced on a piecemeal basis. The first stage in the adoption of an electronic traffic control system would not contemplate the use of any auxiliary equipment in the car and would be limited to isolated portions of the highway system where special hazards might exist, such as intersections, and hills and curves with poor visibility.

A versatile new weapon in the campaign against driving hazards on the nations highways was recently unveiled in the state of Nebraska. In a field demonstration at the intersection of Nebraska Highway 2 and U. S. 77 south of Lincoln, an electronic system for vehicle control which required no special equipment in motor vehicles, was revealed by the Nebraska Department of Roads and the Radio Corporation of America (RCA).

To highway officials from many states and representatives of the press, radio, and television, the novel system was shown detecting and reacting to the passage of vehicles over a specially equipped 320-foot section of highway to cause the following actions:

1. Operation of lights giving right-of-way at a point of merging traffic.
2. Warning a driver when he followed too closely behind another vehicle.
3. Indicating to a driver the presence of an obstacle in the highway ahead.
4. Simulating the automatic guidance of a car along its traffic lane.

The highway officials were told that the experimental system is "an extremely promising development that may well mark a turning point in the nation-wide campaign to reduce the heavy toll of accidents on our highways."

It was emphasized that the present test installation represented a purely experimental step designed to study and demonstrate the principles of electronic vehicle control and to evaluate certain features of the present system. It was indicated that a logical next step would be the development of a more extensive test facility, such as a complete mile or two of highway equipment with a variety of safety devices and including fully equipped test vehicles.

The present test installation was designed by the engineering staff of the Nebraska Department of Roads. The system itself, described basically as a series of electronic elements buried in and along the highway to detect and respond to the passage of vehicles, was developed to its present stage by an RCA Laboratories research team. The system is based on a concept demonstrated by Dr. V. K. Zworykin and his group at RCA's David Sarnoff Research Center, Princeton, N. J., in 1953.

It was emphasized that the system is "compatible" in its ability to perform many important safety functions on the highways under present conditions, even without the installation of special equipment in automobiles.

The electronic elements buried in the highways can be used in their present form to activate many different arrangements of warning lights and signals placed along the right-of-way to do many things that would contribute substantially to greater safety in driving.

Among the possible present applications in this category are:

1. Give the right-of-way to one of two or more vehicles approaching a point of merging traffic.
2. Warn a driver of the presence of an obstacle, such as a parked vehicle approaching in his lane, over a hill or around a curve.
3. Warn a driver of other vehicles' approach in the other lane, "indicating whether it is safe for him to pull out around an obstacle such as a parked vehicle in his lane."
4. Warn a driver when he is following too closely behind the vehicle ahead in his lane.
5. Warn a driver when he is traveling too fast.
6. Operate traffic lights at intersections "with greater flexibility than is possible with present techniques."

All of the foregoing actions can be accomplished without actual control of the vehicles themselves, but rather by means of a series of lights along the edge of the highway, which go on automatically as a vehicle passes and remains on until the vehicle is a specified distance beyond the light. In the case of vehicles approaching from the opposite direction on hills or curves, the system can respond to their presence by operating a warning light or signal placed within view of the driver from whom the approaching vehicles themselves are hidden.

These applications require no alterations or special equipment in automobiles or trucks and, therefore, can be introduced at various locations in the near future. A logical next step, but one that will require more extensive testing as

well as the co-operation of industry and the driving public, is the addition of simple receiving equipment in vehicles.

This step could be accomplished in two stages. First, simple receiving equipment for indication and warning only could be provided as a removable unit upon entrance on a turnpike or purchased by the driver for installation in his own car. The second stage would be the installation of receiving and control equipment as an integral part of the vehicle by the manufacturer.

With such equipment, the signals generated by the detecting elements in the road will control brakes, steering gear, and engine speed to provide fully automatic driving along entire highways or in specific areas where it may be advisable for reasons of safety.

Dr. Zworykin attended the demonstration and pointed out that the electronic vehicle control system in its entirety would apply to the highways "a set of features comparable to the block signal and control systems used on railroads." He stated that future highways would substantially reduce the element of risk that is involved today because of the carelessness, ignorance, or sudden physical disability of the driver.

The electronic detector units used in the demonstration, which form the basis of the system, can easily be installed in existing highways as well as in new roads. The existence of road installation would induce automobile manufacturers to offer as accessories the automatic devices that would employ the signals from the guidance cable and the buried antenna systems to control steering and braking. Here, too, the introduction of improvements could be on a step-by-step basis.

Thus, in the first step, automatic control would simply keep the car in lane and adjust its speed to prevent collisions and obey traffic signals. The driver would have to take over whenever he desired to pass a car ahead of him or to change routes. In a more advanced stage of the road installation and vehicle equipment, automatic control devices would sense suitable opportunities for passing and would change routes in response to a program preset on an electronic computer in the vehicle. The driver would have to take over only as he left the high-speed road system.

Here, of course, we are looking into a relatively far distant future in which the human factor will have been entirely removed as a cause of accidents on tomorrow's equivalent of our present developing network of turnpikes and superhighways. At the same time, this look ahead is more than a statement of a remote ideal, for the technique of electronic controls provides us even now with a means for starting to progress by stages to the ultimate goal. With the coming of each stage, we shall gain substantially in increased driving safety.

The final stage of automation can be visualized, particularly with reference to long-distance motor hauling. In this manner, automatically operated trucks on special truck routes could haul goods between marshalling yards, where they would be delivered and picked up by local crews. On the long-distance truck routes the trucks would proceed at uniform speed and safe intervals, being automatically transferred to the road shoulders upon any mechanical failure or failure of the control equipment. Service crews at control stations along the route would stand by to correct the defect and return the repaired vehicle to the road traffic.

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

BATTERIES OF TODAY. By A. B. Garrett. Research Press, Inc., 137 N. Perry St., Dayton 2, Ohio, 1957. 216 pages, 5¼ by 8 inches, bound. $9. An exposition in terms readily understandable to the layman of the principles and operation of storage batteries, primary batteries, classical cells, fuel cells, solar batteries, and nuclear batteries.

DIGITAL DIFFERENTIAL ANALYZERS. AN APPLICATIONS MANUAL FOR DIGITAL AND BUSH TYPE DIFFERENTIAL ANALYZERS. By G. F. Forbes. Published by G. F. Forbes, 10117 Bartee Ave., Pacoima, Calif., fourth edition, 1957. Various paging, 8 ¾ by 11 inches, paper. $5. Basic integrator mechanisms for the generation of experimental trigonometric, algebraic, and inverse trigonometric functions are shown, and adders and servos and the uses discussed. Applications to scientific and engineering problems are illustrated, especially in chapters dealing with the calculation of the trajectory of an interplanetary rocket, curve analysis, and various common functions. This edition is reproduced from the third edition with additions and corrections.

ENGINEERING PROGRESS AND THE OIL INDUSTRY. Report of the Summer Meeting of The Institute of Petroleum, 1957. Published by the Institute, London, England, 1957. 168 pages 5 ¾ by 8 ¾ inches, bound. 30s. The seven papers included in this volume reflect the mutually stimulating influence of the petroleum industry and other engineering fields. The several authors itemize and discuss the contributions of civil, mechanical, electrical, marine, chemical, and metallurgical engineering to the developments in design and fabrication of the modern petroleum plant and its equipment.

A HISTORY OF TECHNOLOGY. Volume 3—From the Renaissance to the Industrial Revolution, c 1500-c 1750. Edited by Charles Singer and others. Oxford University Press, 114 Fifth Ave., New York 11, N. Y., 1957. 766 pages, 7¼ by 10 inches, bound. $26.90. The third of a five-volume history which will cover the subject from the Old Stone Age to the latter part of the 19th Century. The present volume gives due attention to the pendulum clock, inquiries into the properties of metals, and to improvements in scientific instruments—developments of significance for future centuries—as well as to the great wooden ships, huge machines for raising water, and massive stone buildings that were the culmination of long technological traditions. Like others in the series, the volume is superbly printed and illustrated.

INSTALLING ELECTRONIC DATA PROCESSING SYSTEMS. By R. G. Canning. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1957. 193 pages, 5¾ by 9 ¼ inches, bound. $6. By means of a generalized case study combining the experiences of a number of companies, the author shows how to analyze and solve the problems that are involved in planning for installation, programming, actual installation, conversion to electronic data processing, and in early phases of operation. The conversion of production specification, parts requirements, work-in-process, employee, machine, and other files is treated.

MATERIALS HANDLING EQUIPMENT. By D. O. Haynes. Chilton Company, Chestnut & 56th Sts., Philadelphia 39, Pa., 1957. 636 pages, 6 by 9½ inches, bound. $17.50. Virtually an encyclopedia of materials handling equipment, this volume shows how the various machines function and what they can do. Six of the seven sections are devoted to principal types of machinery—transporting, elevating, conveying, transferring, self-loading, and bulk-handling. A seventh section is devoted to accessories. Over 2,000 line drawings illustrate the internal parts of the machines discussed.

NATIONAL CONFERENCE ON THE ADMINISTRATION OF RESEARCH, PROCEEDINGS, 1956. Published by the Pennsylvania State University Press, University Park, Pa., 142 pages, 8½ by 11 inches, paper. $4.50. The 18 papers presented at this conference cover a variety of subjects from the evaluation of administrators to the financial evaluation of research operations. Specific papers deal with the following sample topics: management science techniques for research administrations, operations research, efficient manpower use, motivation of research workers, research and creativeness, and selection of research ideas.

POLYTHENE. Edited by A. Renfrew, P. Morgan. Interscience Publishers Inc., 250 Fifth Ave., New York 1, N. Y., 1957. 567 pages, 6 by 10 inches, bound. $18.50. Some 38 British and American specialists have contributed the 32 chapters making up this comprehensive and critical appraisal of available data on polyethylene (called "polythene" in England). Grouped under three main headings—manufacture and properties, processing techniques, and applications—the separate chapters cover dielectric and mechanical properties, specifications and tests, irradiated and modified polyethylene, extrusions and injection molding, centrifugal casting, sprayed and dip coating, cables, piping, etc. References are listed after most chapters and the volume is indexed.

PROGRESS IN SEMICONDUCTORS, VOLUME 2. Edited by A. F. Gibson and others. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1957. 280 pages, 6 by 9½ inches, bound. $10.50. The second in a series of volumes designed to help specialists keep informed on advances in semiconductors and related fields. The following papers are included: semiconductor alloys, properties of the III-V compound semiconductors, radiation effects in semiconductors, lifetimes of free electrons and holes in solids, production of high-quality germanium single crystals, impurities in germanium, high electric field effects in semiconductors, and theories of electroluminescence.

THE SPECTROSCOPY OF FLAMES. By A. G. Gaydon. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1957. 279 pages, 6¼ by 9½ inches, bound. $9. Extending and bringing up to date the author's previous treatment of the subject, this volume now covers new experimental techniques for controlling flames or for exciting flame-type spectra in special sources, including new burner types, low-pressure flames, flames supported by free atoms, isotope tracer methods, etc. The book deals with flames supported by flourine and other halogens and by oxides of nitrogen as well as by air and oxygen. More than 400 references are cited in this wide-range coverage of flame investigation.

TECHNIQUES OF PLANT MAINTENANCE AND ENGINEERING, 1957. Published by Plant Maintenance Show, Inc., 341 Madison Ave. New York 17, N. Y., 1957. 273 pages, 8 ¼ by 11 ¼ inches, bound. $10. This book is a record of the technical sessions held concurrently with the eighth National Plant Maintenance and Engineering Show, Cleveland, Ohio 1957. It contains 31 papers with discussions covering many phases of maintenance: power distribution equipment, small plant maintenance, rotating electrical ma-

chinery, training personnel, cost controls, and a wide range of maintenance problems in various plants such as metalworking, steel mills, foundries, paper mills, petroleum refineries, and rubber mills.

TRANSISTOR ELECTRONICS. By David DeWitt, A. L. Rossoff. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N. Y., 1957. 381 pages, 6 by 9 ¼ inches, bound. $8. This book, intended for graduate engineers and advanced electrical engineering students, originated in a course given for practicing engineers at the Radio Receptor Company. Early chapters give a concise but thorough grounding in important semiconductor processes; later chapters deal with practical aspects of circuits and devices including amplifiers, switching circuits, mixers, and demodulators. Problems for class use or self-study and a brief selected bibliography are included.

VOLTAGE STABILIZED SUPPLIES. By F. A. Benson. MacDonald & Co. (Publishers) Ltd., London, W. 1, England, 1957. 370 pages, 5 ½ by 8 ¾ inches, bound. 50s. Treats the basic principles, characteristics, and applications of the various methods of stabilizing either a-c or d-c power supplies. Three chapters are devoted to the nature and limitations of glow-discharge tube circuits. Other chapters cover corona stabilizers for higher voltage, thermionic valve circuits, magnetic saturation, and miscellaneous stabilizers, including those employing nonlinear elements, transductors, or grid-controlled rectifiers. There is a bibliography of over 1,000 references.

WELDING HANDBOOK. American Welding Society, 29 W. 39th St., New York 18, N. Y., fourth edition, section one, 1957. Various pagings, 6 ¼ by 9 ¼ inches, bound. $9. This standard reference work is now to appear in five volumes, of which this is the first. It contains the fundamentals of welding: terms, general engineering tables, welding metallurgy, properties of welded joints and treatment of weldments, cost estimation, inspection and testing methods, statistical control of weld quality, and safety practices. An extensive and detailed index provides quick reference to the contained information.

TECHNICAL LITERATURE

The following recently issued technical literature may be of interest to readers of *Electrical Engineering*. All inquiries should be addressed to the issuers.

ELECTRICAL INSULATING MATERIALS STANDARDS. The upsurge in the use of electrical power, creating a demand for new and better insulating materials, is reflected in the 1957 edition of this widely used book. It contains extensive revisions and new standards to keep the contents abreast of current industrial developments. It provides an up-to-date and handy compilation of American Society for Testing Materials (ASTM) test procedures and specifications for electrical insulation for use of manufacturers of equipment and those associated with the use and distribution of electrical power. The test methods are widely used for evaluation of potential new or improved insulating materials. Specifications provide the consumer with a basis for purchase of insulating materials of known quality. There are 35 standard methods, 32 tentative methods, and 17 specifications in this 692-page book. Of these, 15 are new or recently revised. Also included is a suggested liquid displacement method for dielectric constant and dissipation factor of polyethylene. Copies of this book may be obtained from the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., at $6 each.

FEDERAL FUNDS FOR SCIENCE VI. The latest in a series on the Federal Government's research and development budget, in addition to data on expenditures for scientific research and development, including both funds for conduct of research and development and for increase of R&D plant, the report includes an analysis of the Government's financial obligations in terms of administering agencies, character of work, scientific fields, and organizations performing the work. In fiscal 1957, the Department of Defense and the Atomic Energy Commission accounted for 85% of the total funds. Along with these two agencies, six other agencies—Health, Education, and Welfare; Agriculture; National Advisory Committee for Aeronautics; Interior; National Science Foundation, and Commerce—were responsible for all but 1% of the research and development budget. Copies may be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., for 35¢.

MONOGRAPH ON ALLOYING METALS. The fourth volume in a new monograph series issued by Alloys of Iron Research provides a valuable reference source for engineers, metallurgists, and others concerned with effects of certain alloying metals on carbon steel and on both simple and complex alloy steels and cast iron. The present 533-page work, a correlated summary of important literature on the use of boron, calcium, columbium, and zirconium as alloying metals, will be indispensable to the designer of metals to be used at very high temperatures and under high pressures. Established in 1930, Alloys of Iron Research is one of Engineering Foundation's oldest and most important projects. The new reference, entitled "Boron, Calcium, Columbium and Zirconium in Iron and Steel," is the 15th monograph published and the 4th in a special series that has been in preparation since 1946 to cover the phenomenal advances in metallurgy made during the war. Authors of the fourth monograph are R. A. Grange, U. S. Steel Corporation; F. J. Shortsleeve, D. C. Hilty, W. O. Binder, and C. M. Offenhauer, Electro Metallurgical Company; and G. T. Motock, Olin Mathieson Chemical Corporation. The volume has been carefully reviewed by authorities in the field and approved for publication by the Iron Alloys Committee. John Wiley & Sons has published the fourth monograph for Engineering Foundation. Copies are available from the publisher at 440 Fourth Ave., New York 16, N. Y. at $14.

APPLIED PROTECTIVE RELAYING. This 239-page book prepared and published by Westinghouse Electric Corporation's relay department, is a basic text for class or individual study in the application, setting, and maintenance of protective relay systems. It is designed to be equally useful to practicing relay engineers and to engineers who are indirectly concerned with relay systems; and is an outgrowth of classes taught for several years by Westinghouse engineers. Emphasis throughout is on relay applications and not on relay design. A 21-page appendix contains much useful relay engineering data. Copies are available at $3 from the Department of Technical Information, Westinghouse Electric Corporation, P. O. Box 2278, Pittsburgh 30, Pa. Make all checks or money order, which must include all applicable state or city use or sales taxes, payable to the Westinghouse Electric Corporation.

BIBLIOGRAPHIES. A comprehensive set of bibliographies of articles which have appeared in the *Welding Journal* during the past 20 years and covering practically every welding process, metal, and material has been prepared by the American Welding Society (AWS). This set of bibliographies is one of the most exhaustive available. Articles are grouped under 28 headings which include such industries as aircraft, railroads, and shipbuilding; processes such as brazing, oxygen cutting, resistance welding, inert-gas metal-arc welding, and submerged arc welding; and metals such as aluminum, cast iron, copper, stainless steel, molybdenum, and zirconium. Listings begin at 1937, all articles on a particular subject are listed during the year they appeared, and cover the 20-year period through December 1957. These will be invaluable to all who require background information on welding, saving days of searching through libraries and technical literature for authoritative information. The set of 28 bibliographies, enclosed in an attractive binder, lists for $5; single bibliographies 50¢. Available from the American Welding Society, 33 W. 39th St., New York 18, N. Y.

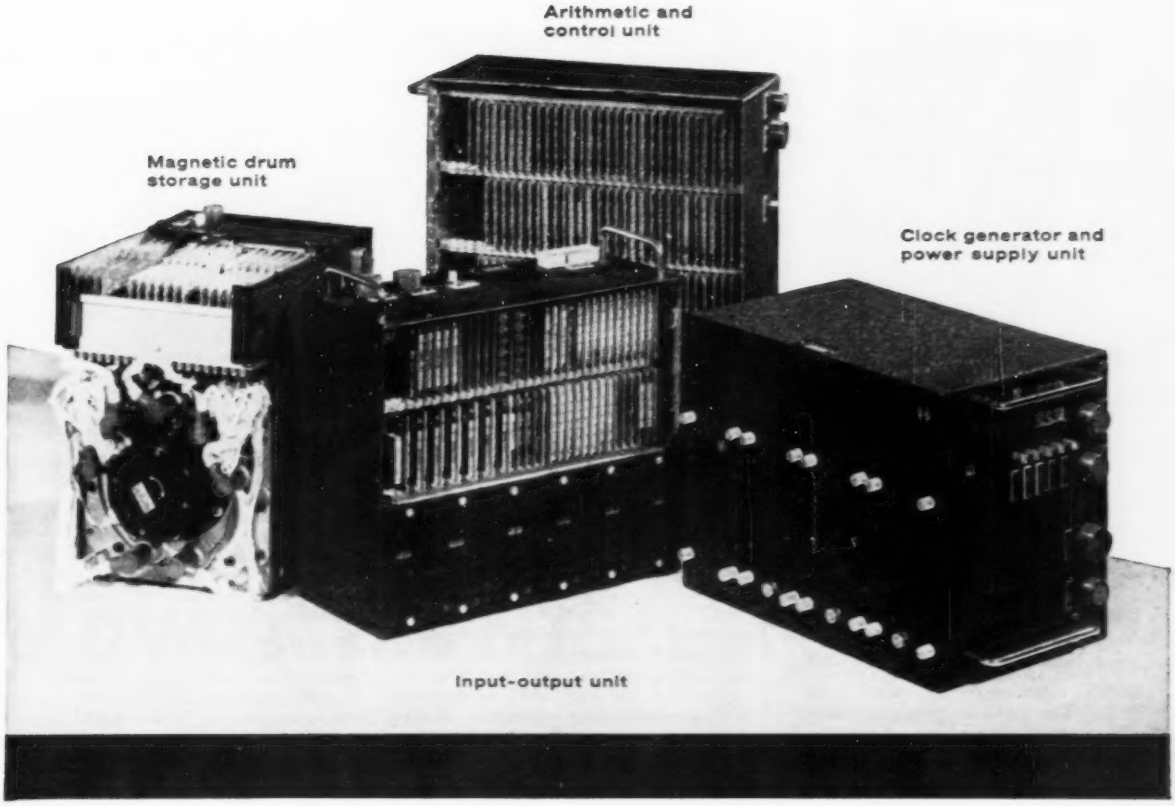
EIA STANDARDS. The following are three new recommended Electronic Industries Association (EIA) Standards: *RS-170*—Electrical Performance Standards, Monochrome Television Studio Facilities (This Standard, from Standards Proposal Nos. 475 and 536, is a revision of *TR-135*). *RS-198*—Ceramic Dielectric Capacitors, Classes 1 and 2 (This Standard from Standards Proposal Nos. 522 and 543, is a revision of *REC-107-A*). *RS-201*—Recommended Standards for Export Receivers (This Standard, from Standard Proposal No. 547, is a reaffirmation of *REC-112*).

ADHESIVE BONDING OF METAL BIBLIOGRAPHY. This is a selected list of over 150 annotated references to books and magazine articles published from 1947 to 1957, covering all aspects of adhesive metal-to-metal bonding, including references to theory, technology, properties, and methods of application. In addition to application in the aircraft industry, the references deal with many other products such as tools, machinery parts, electrical apparatus and wiring, pistons, metal window frames, furniture, bicycles, etc. This "ESL Bibliography No. 12" may be purchased from the Engineering Societies Library, 29 W. 39th St., New York 18, N. Y. for $2.

ATOMIC ENERGY FACTS. Issued by the U.S. Atomic Energy Commission (AEC) to provide industry with up-to-date compilations of information in the atomic energy field, this 216-page volume, illustrated with 86 drawings, photographs, and flow charts, is a handbook on nuclear operations in the United States for industrial management and others active or interested in atomic energy. It combines and organizes material from many AEC sources. Entirely devoted to peaceful uses of atomic energy, it describes the organization and functions of the AEC, technical information services the AEC provides and how to use them, conditions under which qualified individuals and organizations may gain access to classified information, special materials and services available from the AEC, and how to obtain patents and licenses. Other topics discussed include the AEC programs for training and education in nuclear science and technology, co-operation with friendly nations in peaceful applications of atomic energy, activities of major AEC contractors, raw and feed materials, reactor development, and radioisotope development. The volume contains eight appendixes and a catalog of materials standards. The book, paper bound, may be purchased for $2 from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

SURVEY OF ELECTRIC POWER EQUIPMENT. This report combines the results of two studies carried out by the Organisation for European Economic Co-operation (OEEC), concerning equipment used in the electricity supply industry. The two parts are: (1) first survey of the Electricity Committee on the development of capital equipment in the electricity supply industry and its technical characteristics, and (2) tenth survey of the Machinery Committee on the trends of deliveries, orders in hand, and production capacity of European manufacturers of heavy equipment for power stations. These two complementary surveys show the situation as of January 1, 1957, and give an indication of probable trends up to 1960. Copies are available from OEEC Publications Office, Suite 1223, 1346 Connecticut Ave., N. W., Washington 6, D. C., price $2.

THE PUNCHED CARD ANNUAL OF MACHINE ACCOUNTING AND DATA PROCESSING. Management is clamoring for information which this volume presents on these vital subjects. The latest issue, Volume Six, has a management section and an applications section. It features an editorial summary of data processing—all latest equipment complete with pictures and a chronology. Four previous volumes also are available, each of which provides a wide variety of material of interest to both management and operational personnel in practically every type of business, industry, or civilian or Government institutions. (Volume One is out of print.) Each volume contains more than 200 pages and the five volumes are completely cross-indexed. More than 500 articles are included in the five-volume set. The complete set of five volumes is priced at $45 or the latest single volume (Volume Six) at $10.50 (plus postage). The publisher guarantees complete satisfaction. Order directly from The Punched Card Annual, 956 Maccabees Building, Detroit 2, Mich.



The Importance of
DIGITAL TECHNIQUES

Digital techniques constitute one of the important developments which have made possible the recent advances in computers and related equipment for computation, data processing, and industrial and military electronic control.

Digital computers for scientific computation range from small specialized units costing a few thousand dollars, to large general-purpose computers costing over a million dollars. One of these large computers is a part of the Ramo-Wooldridge Computing Center, and a second such unit is being installed early this year.

Electronic data processing for business and industry is rapidly growing based on earlier developments in electronic computers. Data processors have much in common with computers, including the utilization of digital techniques. A closely related field is that of industrial process control. To meet the needs in this field, Ramo-Wooldridge has recently put on the market the RW-300 Digital Control Computer.

The use of digital techniques in military control systems is an accomplished fact. Modern interceptor aircraft, for example, use digital fire control systems. A number of Ramo-Wooldridge scientists and engineers have pioneered in this field, and the photograph above shows the RW-30 Airborne Digital Computer.

The RW-30 is an example of what can be accomplished through the application of digital techniques in conjunction with modern semiconductor components. It performs complete mathematical operations, including multiplications, at the rate of 4000 per second (as fast as large scientific computers). Yet it occupies only 4.19 cubic feet, weighs 203 pounds and uses 400 watts power. It is packaged in four separate units to facilitate installation in aircraft. The magnetic drum memory has a capacity of 2607 21-bit words.

The versatility inherent in digital techniques makes it possible for the RW-30 to handle such varied military aircraft problems as navigation, armament control and bombing, and combinations of these problems, without changes in the RW-30 itself.

The RW-30 also serves to illustrate the balanced integration of systems analysis and product engineering which is a principal objective at Ramo-Wooldridge. Similar programs are in progress on other airborne and electronic control systems, communication and navigation systems, and electronic instrumentation and test equipment. Engineers and scientists are invited to explore openings in these fields at Ramo-Wooldridge.

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CORPORATION
Circle 12 on the card.

INDUSTRIAL NOTES

First Atomic Lamp Production Models. Representatives of the world's nuclear energy industry have seen the first production models of a new line of "atomic lamps" which provide power-free, uninterrupted illumination for periods up to 10 years. The lamps, called Isolites, were developed by United States Radium Corporation, Hanover Ave., Morristown, N. J.

Space Communications Lab. Sending of radio and radar signals across the vast reaches of outer space is being studied by Lockheed Missile Systems Division scientists in a large, new space communications laboratory in Sunnyvale, Calif. Areas to be covered include the effect of outer space's cosmic rays on radar and radio signals, the radar pattern presented by various space vehicle and missile shapes, the effect of the ionosphere on such signals, and the characteristics of various antennas when installed in missiles. For further information contact Lockheed Newsbureau, 745 Chrysler Building, New York 17, N. Y.

Expanded Duct Materials Distribution. Fiberglas duct materials for heating and air conditioning units are now being distributed on the local level to appliance and air-conditioning equipment dealers, sheet metal contractors, and wholesale firms, according to Owens-Corning Fiberglas Corporation, Toledo 1, Ohio. The company's branch offices, located in 60 major U. S. cities, are making arrangements for the local distribution. The company points out it will continue to supply Fiberglas duct materials to original equipment manufacturers.

Safeguard Against Metallic Fires. Mercantile Metals, Inc., has announced a new product, known as *X-8* which has been developed for extinguishing metallic fires. Zirconium, hafnium, lithium, and uranium, now in wide use in nucleonics and atomic energy are highly combustible under certain conditions. Magnesium, calcium, sodium, and potassium are easily combustible under known conditions. All such metallic fires are dangerous and very costly. *X-8* has been developed to reduce hazard and losses from this source for science and industry. The new material, for which patent is pending, is shoveled or poured directly on burning parts, ingots, or scrap piles. *X-8* may be used as a packing material to prevent such fires and has been found particularly effective as an additive to zirconium scrap piles to prevent spontaneous combustion. Many tests have been made under different conditions. For further information, write Mercantile Metals, Inc., P. O. Box 478, Carnegie, Pa.

New Company. Hyperion, Inc., 1447 Washington St., West Newton, Mass., is a new company organized to manufacture a-c to d-c power supplies and d-c to d-c converters. Transistorized circuitry is to be featured in the firm's military and commercial models.

Bakelite. New orange-colored heavy duty tarpaulins are being used by Consolidated Edison Company of New York, Inc., (ConEd) to provide protection from rain or snow for workmen and their equipment on manhole repair work in the city streets. Made of Krene vinyl film, a product of Bakelite Company, laminated to both sides of a nylon fabric interlayer, the new tarpaulins are resistant to mold and mildew, and can be folded and put away wet without fear of rotting and decomposition. One thousand of these tarpaulins are used by ConEd to provide tough protection, yet are light in weight and easy to handle. For further information contact Bakelite Company, Division of Union Carbide Corporation, 260 Madison Ave., New York 16, N. Y.

Complete Automation Soldering. Now a reality according to Fusion Engineering Co., 17921 Roseland Ave., Cleveland 12, Ohio, completion of preliminary tests on this new procedure of automation soldering combines the use of new paste type solder alloys, tailor made for special automatic dispensers together with the latest improvements in automatic heating equipment. The company's latest paste type alloys consist of pure solder powders combined with special fluxes and neutral binders to form a stable paste. These pastes are preplaced in the joint area previous to soldering, using newly developed automatic or semiautomatic dispensers. These dispensers are capable of metering the exact amount of paste up to one one-hundreth of an ounce of material and will deposit this material in dots, stripes, or special patterns as required. Each dispenser can deposit a metered amount of material at the rate of 8,000 dots per hour and with variations can deposit up to 15,000 dots per hour.

Company Formed. The formation of a new company, Data-Control Systems Inc., was recently announced by Dr. R. J. Jeffries, who will serve as the company's first president. The new company will develop, manufacture, and sell equipment in the broad field of instrumentation, with an initial emphasis on advanced forms of radio telemetry systems for aircraft and missiles. The research and development laboratories will be located at 39 Rose St., Danbury, Conn. Manufacturing facilities will be provided on a subcontract basis by several well-known companies in areas of their particular competence. The complete technical program of the new company will include development and application of proprietary products and sponsored research in four principal areas: measurement, computation and data handling, telemetry, and control.

(Continued on page 22A)

65 YEARS OF PIONEERING POWER ADVANCEMENTS...

BROWN BOVERI is proud of the many contributions it has made to *power progress*, a few of which are listed at the right.

It is this advanced thinking. . . . reflected in equipment design and manufacture . . . which has made the name of Brown Boveri synonymous with the finest in power equipment.

BROWN BOVERI CORPORATION
19 RECTOR STREET NEW YORK 6, N. Y.

1891 Pioneered a-c designs for power station and 23 kV transmission system.

1898 First oil circuit breaker in practical service.

1901 Development by C. E. L. Brown of the smooth rotor now universally adopted for turbo-generators.

1902 First multiple-break oil circuit breaker.

1906 First blast furnace turbo-blower in the world.

1906 First turbo-compressor in the world for gas turbines.

1910 First gas turbine on the Holzwarth principle

1915 First rectifier installation in a traction substation.

1917 First aero-engine supercharger in the world (mechanically driven).

1923 First exhaust driven turbines and turbo-blowers for pressure-charging of diesel engines.

1928 First reliable high-speed distance relay for selective isolation of faulty power lines.

1931 First high-efficiency, high-pressure, axial-flow compressor which paved the way for the gas turbine with constant-pressure combustion.

1932 First steam generator fired under pressure (Velox boiler) with supercharging set driven by exhaust-gas turbine, for oil or gas firing.

1933 Composite rotor for turbogenerators.

1933 First Brown Boveri airblast circuit breaker for 13,000 volts.

1937 First gas-turbine-driven compressor installation in the world for the pressure-charging of a chemical process combined with production of energy. (Houdry Process).

1939 First serviceable gas turbine (4000 kW).

1940 First gas-turbine locomotive in the world.

1950 First Brown Boveri Mechanical Rectifier for 16,000 amps at 150 volts, or 8,000 amps at 400 volts.

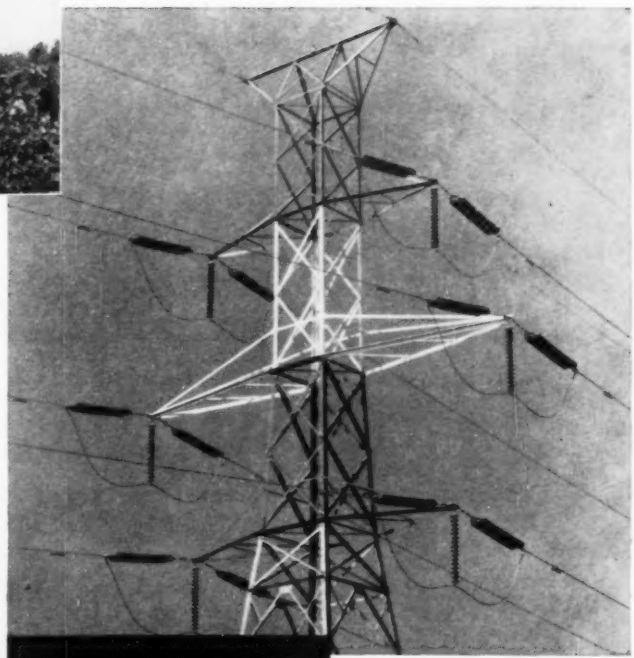
1951 Breaker tests with a Brown Boveri 220-kV airblast circuit breaker in the Grand Coulee switchyard of the Northwest Power Pool, with the largest power concentration in the world. Interrupted power up to 7,800 MVA symetrical.

1952 Outdoor Airblast Breaker in the first 380-kV system in the world.

1955 Complete 6,200 kW mobile gas turbine power station, mounted in two special railroad cars, put into service in Mexico.

For more information circle 13 on reader service card.

MORE Lapp 25,000-lb. insulators for NIAGARA-MOHAWK 230-kv system



This new Huntley-Gardenville line on Niagara-Mohawk Corporation's system is 21 miles long, 230 kv, double circuit. Tower heights average 123 feet. Maximum span is 1250 feet, minimum span 400 feet. Conductor is 1192.5 MCM ACSR. Insulators used include Lapp No. 8200 (15,000-lb.) units in suspension strings; and Lapp No. 5960A (25,000-lb.) units, two-string yoked, for dead-ends, as shown here.

Niagara-Mohawk is one of many utilities whose service records on Lapp suspension insulators merit confidence. Lapp was pioneer in belief . . . and demonstration . . . that suspension insulators could combine electrical security, long life and consistent high strength. For your new construction at EHV . . . and regular transmission voltages . . . Lapp insulators will give you an extra margin of security in all these characteristics.

Lapp Insulator Co., Inc., Le Roy, N. Y.

Lapp

For more information circle 14 on reader service card.

Ampli-Bond Trade-Mark

PRE-INSULATED TERMINALS

for heavy-duty wires!

Ampli-Bond is the first and only terminal with bonded insulation and insulation support for copper wire sizes 8 through 4/0.

ASK ABOUT
amp's Creative Approach
TO BETTER WIRING

Bonded insulation, withstanding a minimum of 6000 volts, insures dielectric value. . . . An insulated metal reinforcing ring grips the insulation and protects the wire from the weakening effects of vibration and bending. . . . The terminal body is electro-tinned for high conductivity, and the dimpled inner barrel increases the contact surface and tensile strength. . . . Assures low millivolt drop.

The A-MP Dyna-Crimp Tool, with interchangeable heads and dies, crimps Ampli-Bond terminals rapidly, easily and uniformly.

Consult your local A-MP Sales Engineer or write to Harrisburg for further information.

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Japanese Distributors: Oriental Terminal Products Co., Ltd., Tokyo, Japan

For more information circle 15 on reader service card.

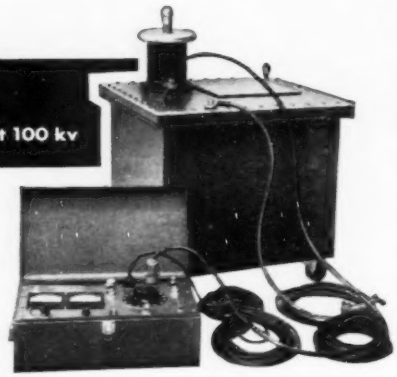
BIDDLE DIELECTRIC TEST EQUIPMENT

. . . for measuring direct current at voltages up to 100 kv when applied to the insulation of generators, transformers, bushings, cable, etc.

New

MODEL 2

current output 6 ma continuous at 100 kv



More and more engineers are leaning to d-c testing with voltages equal to or somewhat greater than equivalent peak alternating voltages. Their experience and increased knowledge and appreciation of the advantages of testing with direct voltage have accelerated the need for test equipment to meet field requirements.

IMPORTANT FEATURES

- Well-designed provisions for utmost safety
- Simple operation and reliable performance
- Excellent output voltage regulation
- Compact, mobile design
- Facilities for voltage and leakage current measurements

IMPORTANT APPLICATIONS

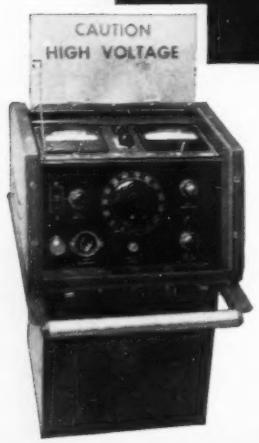
. . . *in development* . . . for testing the d-c dielectric strength of insulating materials and the adequacy of the electric design of insulation in any type of electrical equipment.

. . . *in production* . . . for non-destructively detecting defects in the insulation of electrical equipment due to design, material, and workmanship.

New

MODEL 1-A

3 ma continuous at 40 kv



. . . *in maintenance* . . . for non-destructively detecting unreliable condition of insulation of new or repaired electrical equipment. Preventive maintenance tests on important rotating equipment, cable, switchgear, etc., result in appreciable savings.

For important details regarding these units and information on the subject of high voltage d-c testing *write for our New Bulletin 22-EE.*

B-800

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ELECTRICAL TESTING INSTRUMENTS • SPEED MEASURING INSTRUMENTS
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BULLETIN 22-EE

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Company_____
Address_____
City_____ Zone____ State_____

For more information circle 16 on reader service card.

Industrial Notes

(Continued from page 18A)

Corporate Name Change. Haydon Manufacturing Company, Inc., manufacturer of timing motors and devices, of Torrington, Conn., a subsidiary of General Time Corporation, 109 Lafayette St., New York, N. Y., announces that the business of Haydon Manufacturing Company, Inc., will be conducted by Haydon Division of General Time Corporation, 245 E. Elm St., Torrington, Conn., under the direct supervision and management of the present officers and personnel of Haydon Manufacturing Company, Inc.

Foto-Video Expands Activities. This company has announced that it has acquired a new 10,000 square foot plant in Cedar Grove, N. J. as part of a general expansion program. Established in 1954, Foto-Video Laboratories, Inc., manufactures a line of testing and control instruments, amplifiers, monitors, sync generators, etc., for television networks and studios and for industrial television applications. For further information contact Foto-Video Laboratories, Inc., 36 Commerce Rd., Industrial Village, Cedar Grove, N. J.

Solion Energy Transducer. Commercial development of the solion, an electronic device that may replace the transistor at frequencies below 100 cycles per second, is being jointly carried on by National Carbon Company, Division of Union Carbide Corporation, and Texas Research Associates. Based on both electrochemical and fluid flow principles, the solion is extremely sensitive, and its low power requirements make it ideal for remote and unattended devices. Compared to conventional electronic circuits, the solion is particularly efficient at frequencies below one-tenth of a cycle per second. For further information on the solion, write to W. H. Fritz, Manager, Electronics New Products Department, National Carbon Company, P. O. Box 6056, Cleveland 1, Ohio.

Broadview Research Expands. This company, which has been active for a number of years in the areas of computer application, marketing research, attitude surveys, and land utilization studies, as well as physics, chemistry, engineering, and natural resources research, announces the opening of new quarters in downtown San Francisco, Calif. The new offices feature a ground floor data processing center open to observation from the street. The basic equipment is an *ALWAC III-E* large capacity digital computer operating with paper tape and punched cards. The company staff of trained specialists is available for analysis and programming either for their own computer or for other computing machines. For further information please contact Broadview Research Corporation, 1127 Chula Vista, Burlingame, Calif.

(Continued on page 26A)

NEW! "Feather-touch" PUSH-to-TEST PILOT LIGHT

Added to Square D Oil-Tight Pushbutton Line

Completely oil-tight, even when depressed

Pressure connections eliminate internal wires

Positive contact "feel" in test position

No additional panel space required

Choice of 6 color caps

Full range of voltage ratings

Mounts interchangeably with oil-tight pushbuttons and selector switches

OIL-TIGHT OPERATORS

Standard Button

Mushroom Button

Selector Switch

Coin-Operated Selector Switch

Key-Operated Selector Switch

Selector Pushbutton

Stop Button Lockout

Start Button Lockout

Maintained Contact Attachment

Selector Switch and Pushbutton Lockout

NEW!

4-Position Joystick Operator

Wobble Stick Operator

Neoprene Cap

Here's why Square D Pushbuttons are preferred —by those who *build* machines—and by those who *buy* them!

Easy to use • Operators require only a single mounting hole for quicker installation. Pressure wire connectors mean simplified wiring.

Longer lasting • All-metal operator construction, anodized aluminum buttons, mean greater mechanical life. Melamine contact blocks with double-break silver contacts assure longer electrical life.

Wide flexibility • Any operator can be used with any contact block to meet all your requirements.

Small size • Only a minimum of panel and back-of-panel space is required.

Variety of contacts • Contact block arrangements include single-pole double-circuit, duplex double-circuit, tandem duplex, three-position duplex, and overlapping contacts.

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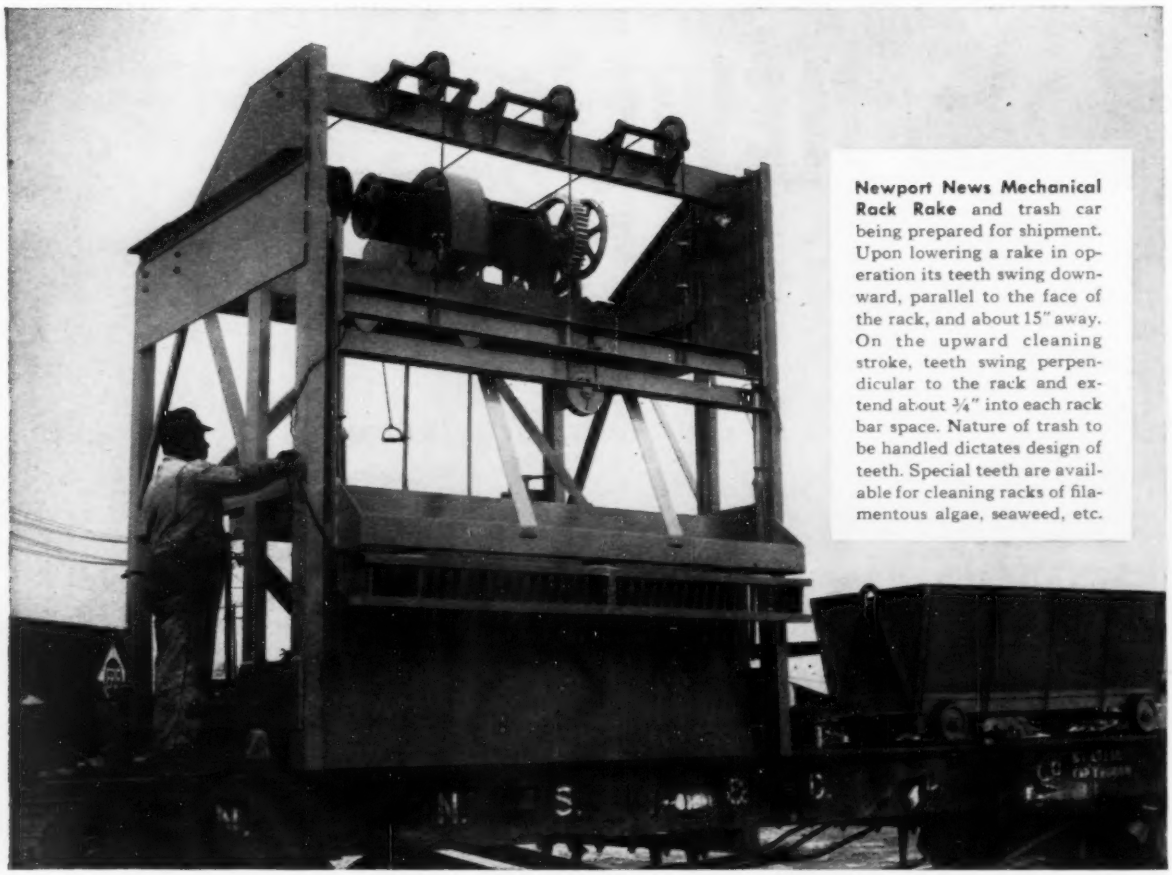
***FOR COMPLETE INFORMATION** on oil-tight pushbuttons, send for Bulletin 9001-T to Square D Company, 4041 North Richards Street, Milwaukee 12, Wisconsin.*

EC&M HEAVY INDUSTRY ELECTRICAL EQUIPMENT...NOW A PART OF THE SQUARE D LINE

SQUARE D COMPANY

For more information circle 17 on reader service card.



Newport News Mechanical Rack Rake and trash car being prepared for shipment. Upon lowering a rake in operation its teeth swing downward, parallel to the face of the rack, and about 15" away. On the upward cleaning stroke, teeth swing perpendicular to the rack and extend about ¾" into each rack bar space. Nature of trash to be handled dictates design of teeth. Special teeth are available for cleaning racks of filamentous algae, seaweed, etc.

Positive cleaning action calls for guided rack rakes

Excessive loads of trash cannot push a Newport News rake away from the racks.

And there's no chance of the rake *riding over trash* on the upward cleaning stroke. Nor will its teeth drop the debris. Because Newport News builds the rake to operate in channel guides... for *positive cleaning action.*

That's why efficient rack cleaning assures the maximum head at intakes and is yours when you put a rugged and dependable Newport News Mechanical Rack Rake on the job.

Maximum width of a single rake is determined by design of the forebay. Where a single bay is extremely wide, intermediate guides are sometimes installed to reduce width of the rake. Such installation is relatively inexpensive.

A power-operated Newport News Mechanical Rack Rake, under ordinary conditions, enables one man per shift to keep racks clean for a dozen bays, from 5'-6" to 28'-6" in width.

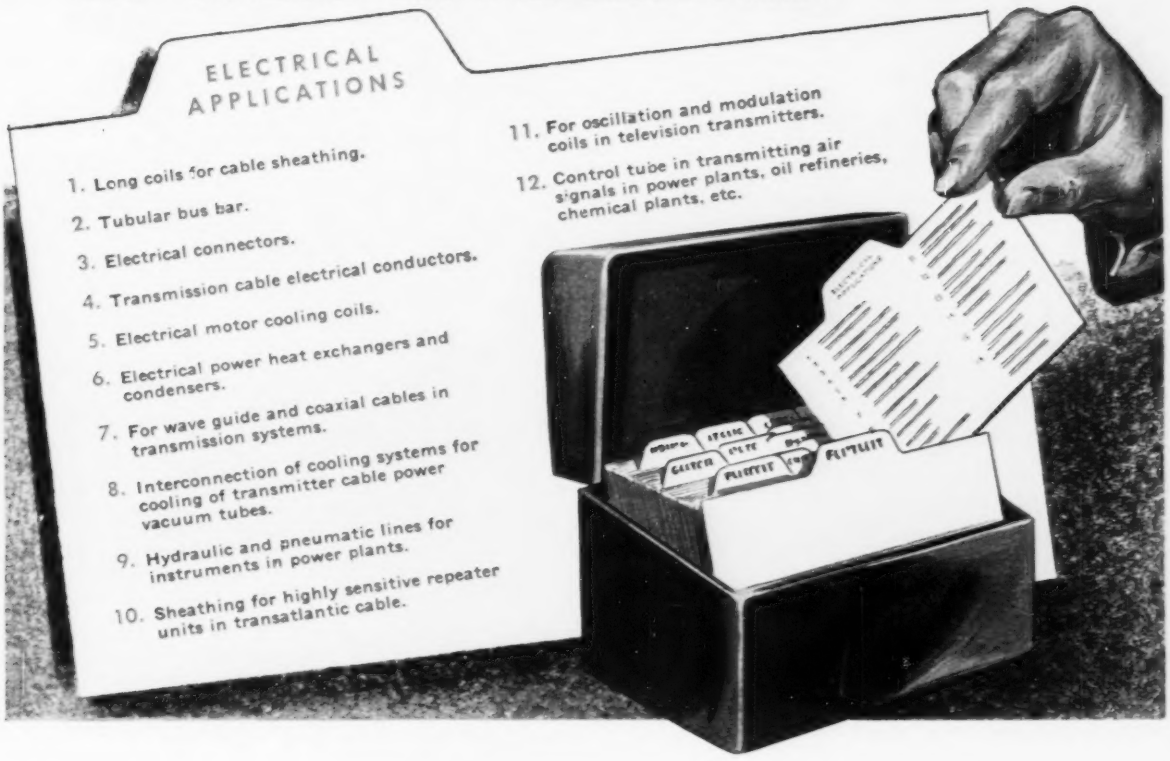
Trash is cleaned from the rake manually, or by a mechanical "sweep", into a flume, a car or onto a trash apron. Local conditions and nature of the trash dictate method of disposal. The many typical installation arrangements fit most needs, but each installation is a custom built job.

We invite inquiries from water users who are troubled with trash. Write for your copy of "RACK RAKE", an illustrated booklet describing the operation and advantages of the Newport News Mechanical Rack Rake.

Newport News
Shipbuilding and Dry Dock Company
Newport News, Virginia

For more information circle 18 on reader service card.

USE WOLVERINE COPPER AND ALUMINUM TUBE IN THESE APPLICATIONS


ELECTRICAL APPLICATIONS
1. Long coils for cable sheathing.
2. Tubular bus bar.
3. Electrical connectors.
4. Transmission cable electrical conductors.
5. Electrical motor cooling coils.
6. Electrical power heat exchangers and condensers.
7. For wave guide and coaxial cables in transmission systems.
8. Interconnection of cooling systems for cooling of transmitter cable power vacuum tubes.
9. Hydraulic and pneumatic lines for instruments in power plants.
10. Sheathing for highly sensitive repeater units in transatlantic cable.
11. For oscillation and modulation coils in television transmitters.
12. Control tube in transmitting air signals in power plants, oil refineries, chemical plants, etc.

BUY WOLVERINE TUBE— IT'S MADE IN AMERICA!

As an electrical manufacturer you'll find at Wolverine a product line designed to meet ALL your tubular needs.

Wolverine copper and aluminum tubing, for example, is available in straight lengths and coils in both prime surface form or with integral fins (Wolverine Trufin®).

You'll also appreciate Wolverine's rigid quality control; the way it packages its products to meet your needs and its IOA program (Individual Order Attention) which assures you of top service right from manufacturing to final delivery.

Before you place your next order get the complete Wolverine story. Write today for your copy of the Wolverine General Products Catalog.

Wolverine Trufin is available in Canada through the Unifin Tube Company, London, Ontario.

CALUMET & HECLA, INC.
CALUMET DIVISION
URANIUM DIVISION
GOODMAN LUMBER DIVISION
WOLVERINE TUBE DIVISION
In Canada
CALUMET & HECLA OF CANADA LIMITED
WOLVERINE TUBE DIVISION
CANADA VULCANIZER & EQUIPMENT CO. LTD.
UNIFIN TUBE DIVISION

WOLVERINE TUBE
DIVISION OF
CALUMET & HECLA, INC.
17248 Southfield Road
Allen Park, Michigan
Manufacturers of Quality-Controlled Tubing and Extruded Aluminum Shapes

PLANTS IN DETROIT, MICHIGAN, AND DECATUR, ALABAMA.
SALES OFFICES IN PRINCIPAL CITIES.

EXPORT DEPARTMENT, 13 EAST 40TH STREET, NEW YORK 16, NEW YORK

For more information circle 19 on reader service card.

MONEY IN THE BANK...
A financial giant, the new Texas National Bank rises on the fabulous Texas Gulf coast. Marcus transformers provide "money in the bank" dependability for power and lighting distribution. For trouble-free performance and greater profits, choose Marcus for your next transformer installation.
Architect: Kenneth Franzheim, Consulting Engineers: Bernard Johnson & Associates, Electrical Contractor: Howard P. Foley Co.
MARCUS
TRANSFORMER CO., Inc.
RAHWAY, NEW JERSEY
Representatives in Principal Cities
"Mark of Quality"
A COMPLETE LINE OF DRY TYPE AND LIQUID-FILLED TRANSFORMERS THRU 5000 KVA

▲ Circle 20 on the card. ▼ Circle 21 on the card.

TELEPHONE AND TELEGRAPH EQUIPMENT

Radio Engineering Products is currently producing a number of types of equipment, electrically and mechanically interchangeable with standard Bell System apparatus.

CARRIER-TELEPHONE EQUIPMENT

C5 Carrier-Telephone Terminal (J68756). A kit for adding a fourth toll-grade channel to existing C systems is available. • C1 Carrier-Telephone Repeater (J68757) • 121A C Carrier Line Filter • H Carrier Line Filter (X66217C).

CARRIER-TELEGRAPH EQUIPMENT

40C1 Carrier-Telegraph Channel Terminal (J70047C) • 140A1 Carrier Supply (J70036A1, etc.) • 40AC1 Carrier-Telegraph Terminal.

VOICE-FREQUENCY EQUIPMENT

V1 Telephone Repeater (J68368F) • Power Supply (J68638A1) • V1 Amplifiers (J68635E2 and J68635A2) • V3 Amplifier (J68649A) • V-F Ringers (J68602, etc.) • Four Wire Terminating Set (J68625G1) • 1C Volume Limiter (J68736C).

D-C TELEGRAPH EQUIPMENT

16B1 Telegraph Repeater (J70037B) • 10E1 Telegraph Repeater (J70021A) • 128B2 Teletypewriter Subscriber Set (J70027A).

TEST EQUIPMENT

2A Toll Test Unit (X63699A) • 12B, 13A, 30A (J64030A) and 32A (J64032A) Transmission Measuring Sets • 111A2 Relay Test Panel (J66118E) • 118C2 Telegraph Transmission Measuring Set (J70069K) • 163A2 Test Unit (J70045B) • 163C1 Test Unit (J70045D).

COMPONENTS AND ACCESSORIES

255A and 209FG Polar Relays • Repeating and Retard Coils, several types • 184, 185, 230A and 230B Jack Mountings.

RADIO ENGINEERING PRODUCTS
1080 UNIVERSITY ST., MONTREAL 3, CANADA
TELEPHONE UNiversity 6-6887
CABLES RADENPRO, MONTREAL

Industrial Notes

(Continued from page 22A)

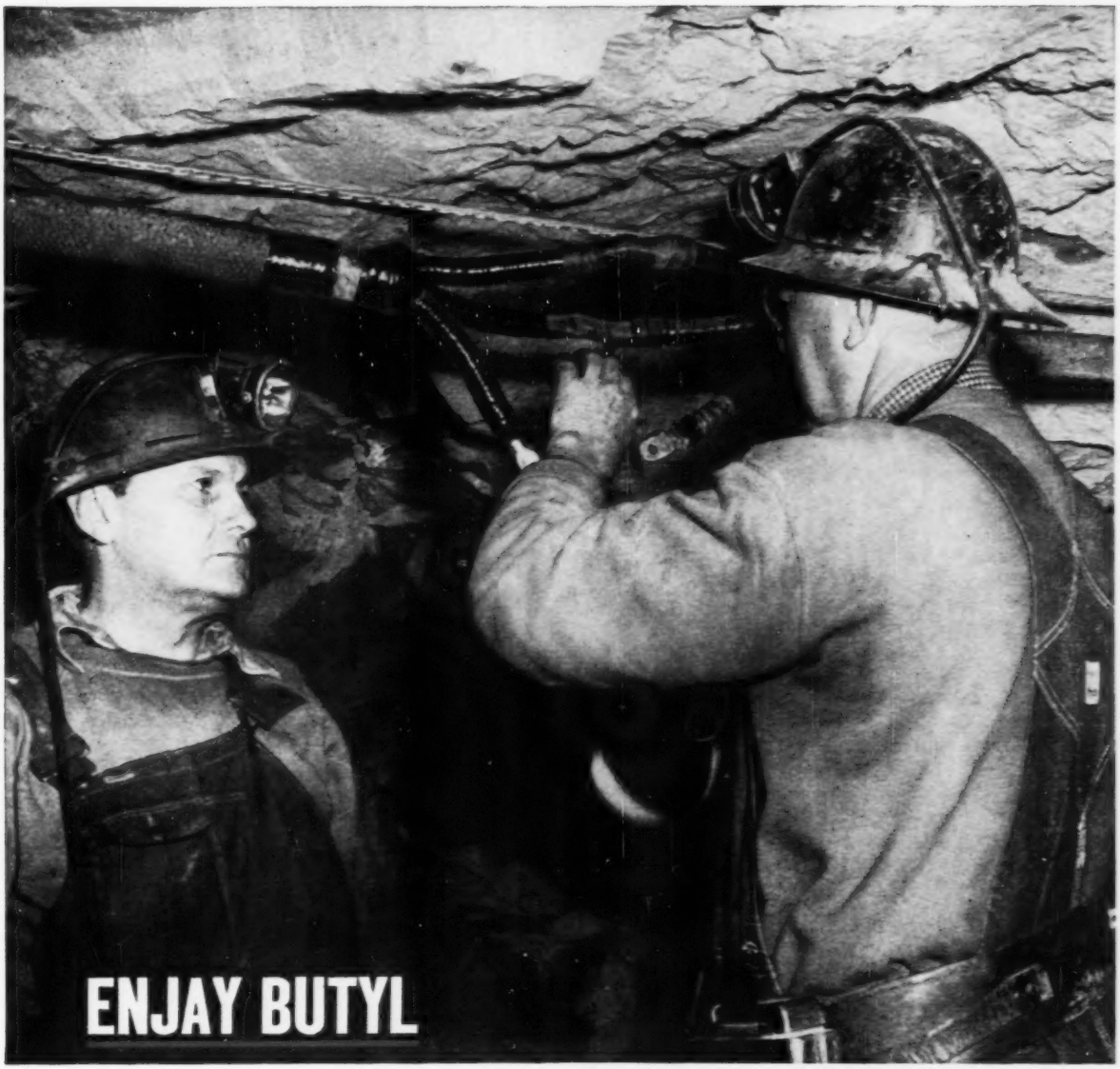
Time Capsule Highlights Dedication Ceremonies. Highlighted by the enshrining of a sealed time capsule containing representative products of this era, the new West Coast research and development center for Elgin National Watch Company's Micronics Division was dedicated December 10, 1957, in Chatsworth, Calif.

The capsule included a clock, specially devised by Elgin engineers for the occasion, which will tick once a year during the "momentous next quarter-century of scientific progress." At the end of the 25-year period, the capsule will be sprung open automatically by the inner mechanism. The enshrined capsule and time piece will be on display in the new building lobby for all visitors. The new facility is on a 4-acre site at 21001 Nordhoff St., Chatsworth, Calif., is equipped with high-precision machine tools, assembly facilities, and testing and inspection gear.

Jackson Moves to Larger Quarters. This manufacturer of custom electronic controls and specialized test equipment, has increased its floor space and added considerably to its manufacturing facilities in a move to new quarters at 695 Johnston St., Akron, Ohio. Jackson Electronic and Mfg. Co. has been primarily engaged in developing and building special test units for use in aircraft production and maintenance, as well as electronic control equipment for the radar, communications, and missile fields. The increased space provided by the new location will be used for expanding production in these fields.

Electrical—Mechanical Testing Laboratory. Announcement has been made by United ElectroDynamics, 1200 Marengo Ave., Pasadena, Calif., of the opening of a new facility to be called the United Testing Laboratories. This move represents a separation and expansion of the research and commercial testing operations carried on by the company for a number of years. The United Testing Laboratories, an integrated electronic and mechanical testing laboratory, is capable of conducting performance tests on inertial guidance systems for missiles and aircraft as well as conducting complete test programs on explosive and fusing systems.

Plant Move. Gibson Electric Company, producer of electric contacts, has announced that it has moved its manufacturing facilities and offices from Pittsburgh to its new plant at Old Wm. Penn Highway, Delmont, Pa.



electrical wonder rubber OFFERS TRIPLE VALUE

Performance! Versatility! Economy! In all three, Enjay Butyl is the world's outstanding rubber value. In laboratory tests, and a wide variety of applications, no other rubber has matched Enjay Butyl's ability to resist ozone and corona, impact and abrasion, moisture and weathering . . . properties that make Enjay Butyl-made products *outstanding* performers.

Underground service cables, transformer housings, high-voltage industrial cables . . . in these, and many other electrical applications, Enjay Butyl outperforms and out-lasts *all other* types of rubber, synthetic *or* natural. *Low-in-cost* and *immediately available*, this truly wonder rubber may well be able to cut costs and improve performance in *your* products. For further information, and for expert technical assistance, contact the Enjay Company.

ENJAY

Pioneer in Petrochemicals

ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.

Akron • Boston • Chicago • Detroit • Los Angeles • New Orleans • Tulsa

ENJAY BUTYL

Enjay Butyl is the greatest rubber value in the world . . . the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

For more information circle 22 on reader service card.

Telemeter
ANY VARIABLE
from Remote Points

Accurate, Fast Acting, Frequency Type Telemeter for Transmission over Wire Lines, Microwave, and Power Line Carrier

Accurate HIGH-SPEED Continuous Telemeter

for VOLTS AMPS WATTS VARS ETC.

•

Built-in Self-Calibrating Circuit

•

The Model 1025 Telemeter Transmitter converts DC mv from thermal converters, etc., to 10-30 cps which frequency modulates a built-in audio tone channel. AC 10 to 30 cps or relay outputs are also available. Receiver detects and demodulates transmitted signal, generating a DC mv for operation of recorders or indicating instruments. Up to 45 telemeters can be multiplexed.

Any communication link, including power line carrier, microwave or wire line may be used.

Over-all accuracy is 1% with a response speed of 1 second. Equipment features a built-in calibration circuit for 10% and 90% receiver check, and 10 cps and 30 cps transmitter check.

Any quantity which may be converted into a DC millivoltage or will operate a slidewire may be telemetered.

WE CAN HELP YOU
Our Applications Department is ready to assist you in your control, telemetering or communications problem. Phone DEerfield 4-3100.

Write for Technical and Application Data.

Radio Frequency LABORATORIES, INC.
Boonton, New Jersey, U. S. A.

Circle 23 on reader service card.

NEW PRODUCTS

All-Metal Magnetic Heads. Offered in a number of standard and special sizes, a line of high-performance, all-metal magnetic head stacks for tape recording applications has been announced, which eliminate oxide and dirt deposits. Maintenance of exceptionally close tolerances in all stages of manufacturing, along with 100% inspection of units, assures high performance. Head gaps are aligned to ±50 microinches, and the line of gaps in each stack is perpendicular to the stack base plane within 0.02 degrees. Heads for magnetic-drum applications are also available on special order. Requests for further information should be directed to Consolidated Electrodynamics Corporation, 300 N. Sierra Madre Villa, Pasadena, Calif. *Circle 200 on the card.*

Shielded Zippertubing. Development of a new laminated type of flexible tubing having a zipper type fastener to provide a shielded casing for multiconductor wiring or cables for the aircraft, guided missile, electrical, and electronic industries has been announced. The new material

Courtesy Western Editorial News Bureau

is a plastic saturated fiberglas backing laminated to aluminum, lead, or magnetic foil. The laminated metal foil provides a method of grounding r-f and uhf at a fraction of the cost of conventional tin or copper shielding with outer jacket. For complete details, write for Catalog Sheet, Zippertubing Company, 750 S. San Pedro, Los Angeles, Calif. *Circle 201 on the card.*

Position or Link Synchronization Control. This control system for conveyors has been recently developed by U. S. Electrical Motors Inc. (USEM). It is used primarily in the automotive and appliance industries. It permits variable speeds of assembly or production conveyors on those applications where absolute position synchronization between two conveyors is required. Position synchronization is accomplished by USEM position or link synchronization control system regardless of the base speed of the conveyors, load variations on the individual conveyors, or differences in conveyor lengths. Position can be held with ±3 inches. For more information, write U. S. Electrical Motors Inc., Box 2058 Terminal Annex, Los Angeles 54, Calif. *Circle 202 on the card.*

"HTC" 50 Series Brake. The new style "HTC" 50 Series brake for use with fractional horsepower electric motors in frames 56-C and 66-C, also integral motor frames *182* and *184* has been announced. The *"HTC" 50* series is the most recent addition to the Stearns Electric Corporation line of brakes designed for use on stub, extended, or through-shaft applications. This model retains the basic single solenoid, lever action, and unitized construction. The brake is available for operation on all standard a-c voltages. For further information, write Stearns Electric Corporation, 120 N. Broadway, Milwaukee 2, Wis. *Circle 203 on the card.*

Instant-Lighting Open-Flame Torch. The *SPX-2* torch is an unpowered open-flame torch which can be lighted instantly with a match at temperatures down to −97 F. It requires no priming generation. Because it burns any type of gasoline or *JP-4* fuel, its design and operation are somewhat different from those of a conventional blow torch. During its starting cycle, it burns a finely atomized fuel-air mixture from the tank, permitting instant lighting at normal or low temperatures. Leaded fuels do not clog its vaporizer and nozzle because temperature is controlled within a range at which residual products are not deposited in these passages. The *SPX-2* torch weighs only 3½ pounds, empty, and has a fuel capacity of one pint. Maximum horizontal dimensions are 6⅝ and 7½ inches with a height of 9¼ inches. For detailed information and specifications on the *SPX-2* torch and other heating equipment for military applications write Hunter Manufacturing Company, 30525 Aurora Rd., Solon, Ohio, requesting catalog brochure *MH-167. Circle 204 on the card.*

Spot Welding Device. The "Rollectrode" is a lightweight device which simplifies and automates spot-welding operations.

It has a selfcontained Mil-Spec motor which powers a welding wheel over the

(*Continued on page 36A*)

CORRECTION: On page 42A (New Products), January 1958 *Electrical Engineering*, the manufacturer's name for "Nylon-Insert Locknut" was inadvertently omitted. For samples of this product write to: Gries Reproducer Corp., 400 Beechwood Ave., New Rochelle, N. Y.

Meters tell the tale but SPECIAL ELECTRICAL ALLOYS do the work

"Steelmaker to the Electrical Industry" is a title we have earned the hard way . . . by the sweat of research and pioneering development. In this modern world of gauges and instruments, of automation, electronics and atomics, the heart of the design is so often some silicon steel, high-permeability alloy, or other special electrical material that we produce. ● When *you* need a steel to do what ordinary steels cannot do—whether electrically or in resisting corrosion, heat, wear or great stress, call on us. *Allegheny Ludlum Steel Corporation, Oliver Bldg., Pittsburgh 22, Pa.*

STEELMAKERS to the Electrical Industry

Allegheny Ludlum

Warehouse stocks of AL Stainless Steels carried by all Ryerson plants

WSW 6042

AL

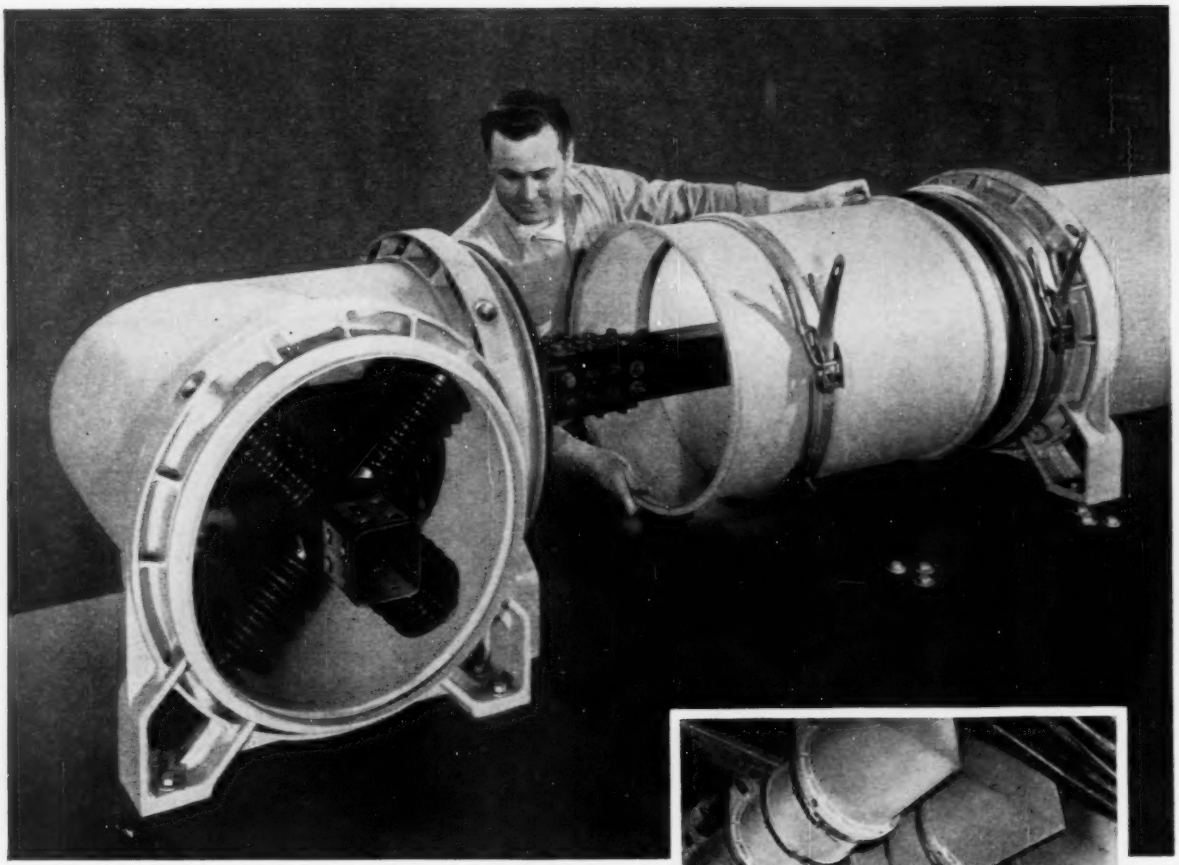
STEELS FOR THE ELECTRONIC AGE

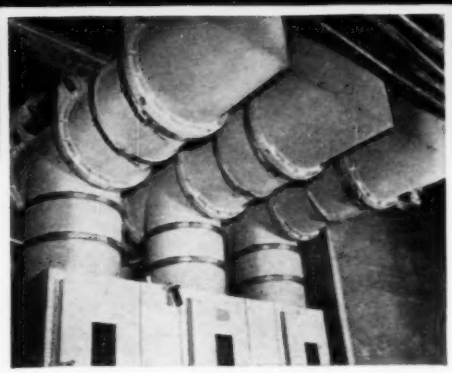
Write for **"MAGNETIC MATERIALS"**

This 32-page book contains valuable data on all Allegheny Ludlum magnetic materials, silicon steels and special electrical alloys. Illustrated in full color, includes essential information on properties, characteristics, applications, etc. Your copy gladly sent free.

ADDRESS DEPT. EL-2.

For more information circle 24 on reader service card.





Custom-built for specific requirements! Heat-treated cast aluminum alloy rings—welded to stationary tubular sections—replace ring gaskets. Porcelain insulators are in compression under normal loads and short circuits. Circular gaskets are fully trapped and self-seating.

For Reduced Installation and Maintenance Costs... DELTA-STAR Metal-Enclosed Isolated-Phase Buses

Delta-Star Metal-Enclosed Isolated-Phase Buses go up faster, and at less cost, than conventional units. Require less time for cleaning, inspection, and maintenance.

Your savings start at installation. Delta-Star pre-assembles 6- or 8-foot longitudinal sections and ships them in lengths as large as your facilities can handle. Ships corners and tees with bus and insulators installed. Reduces gasketing 50% by eliminating longitudinal gaskets.

Your savings continue year after year in inspection and maintenance. You easily remove the telescoping aluminum covers for inspection. You then have a 2'6" space for cleaning and maintenance.

Specially-shaped neoprene gaskets keep out dust and moisture. Spring-loaded clamping assures air-tight seal. Large area ring gaskets permit liberal misalignment of ducts without reducing seal.

For your next installation, check the Delta-Star Isolated-Phase Buses. For full details, call our nearest district representative or write *Delta-Star Electric Division, H. K. Porter Company, Inc., 2437 Fulton Street, Chicago 12, Ill. District offices in principal cities.*

H. K. PORTER COMPANY, INC.

DELTA-STAR ELECTRIC DIVISION

Connors Steel, Delta-Star Electric, Disston, Forge and Fittings, Leschen Wire Rope, Quaker Rubber, Refractories, Riverside-Alloy Metal, Vulcan Crucible Steel, H. K. Porter Company (Canada) Ltd.

Two seconds to "FIRE"...the time when your instrumentation cables must work

Are you responsible for any of the equipment involved in scenes of this kind? Any of the instrumentation or telemetering devices?

If so, you well know how little can be left to chance when a $100,000-plus pre-dawn "shot" is scheduled.

Even minor cable trouble at a time like this can be crucial and costly, especially if it happens on the equipment involved for which *you* are responsible.

That's why it's important for you to insist on electronic cables with *maximum built-in reliability.*

Quiz yourself on cable

Here's how to get this kind of reliability. Ask yourself these questions about the cable that's to go into your own equipment:

1. Who is the cable supplier? Has he:
   a. Thorough knowledge of electronic wiring problems?
   b. Engineering and research skill in developing special cable?
   c. Complete facilities for producing custom-built or specification cable?
2. Are his cable conductors full-size, uniformly annealed and precisely stranded?
3. Are his insulations and coverings uniformly applied compounds that have proved workable, dependable?
4. Can he supply those newly developed materials that might be needed?

You'll find all of these qualifications met in full measure by Rome Cable

Millions of feet of Rome wire and cable have already been installed in electronic gear for military and commercial uses. More is ordered every day.

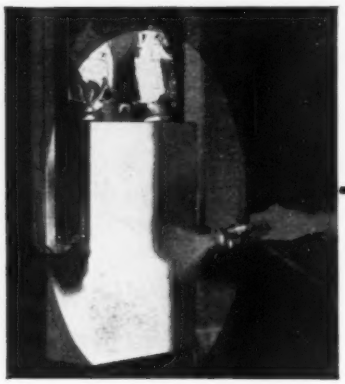
When you require cable that must not fail—or which must meet unusual specifications—we can very probably help you. Simply contact your nearest Rome Cable representative—or write to Department 422, Rome Cable Corporation, Rome, N. Y.

ROME CABLE

CORPORATION

Every VAREX Capacitor Gets this Two-Way Protection

① DURABLE EPOXY ON THE CASE



Epoxy-resin paint used on Varex is most durable finish commercially available for this class of material.

② PACKAGING PROTECTION RIGHT UP TO THE POLE TOP

Extra-heavy carton has gross rating of 160 pounds, more than 40 pounds above heaviest 50-KVAR unit.

At the end of the assembly line, each Varex unit is packaged in a carton having a gross weight rating of 160 pounds. Inside the carton are a special split liner that fits around the capacitor case, two liners that fit over the bushings, and heavy spacers that reinforce the carton and give extra protection at the narrow sides of the unit.

All this protection can be left intact until arrival at the installation site. Then the outer carton is removed but the inner liner is left in place, and can be left in place until the unit is bolted in place.

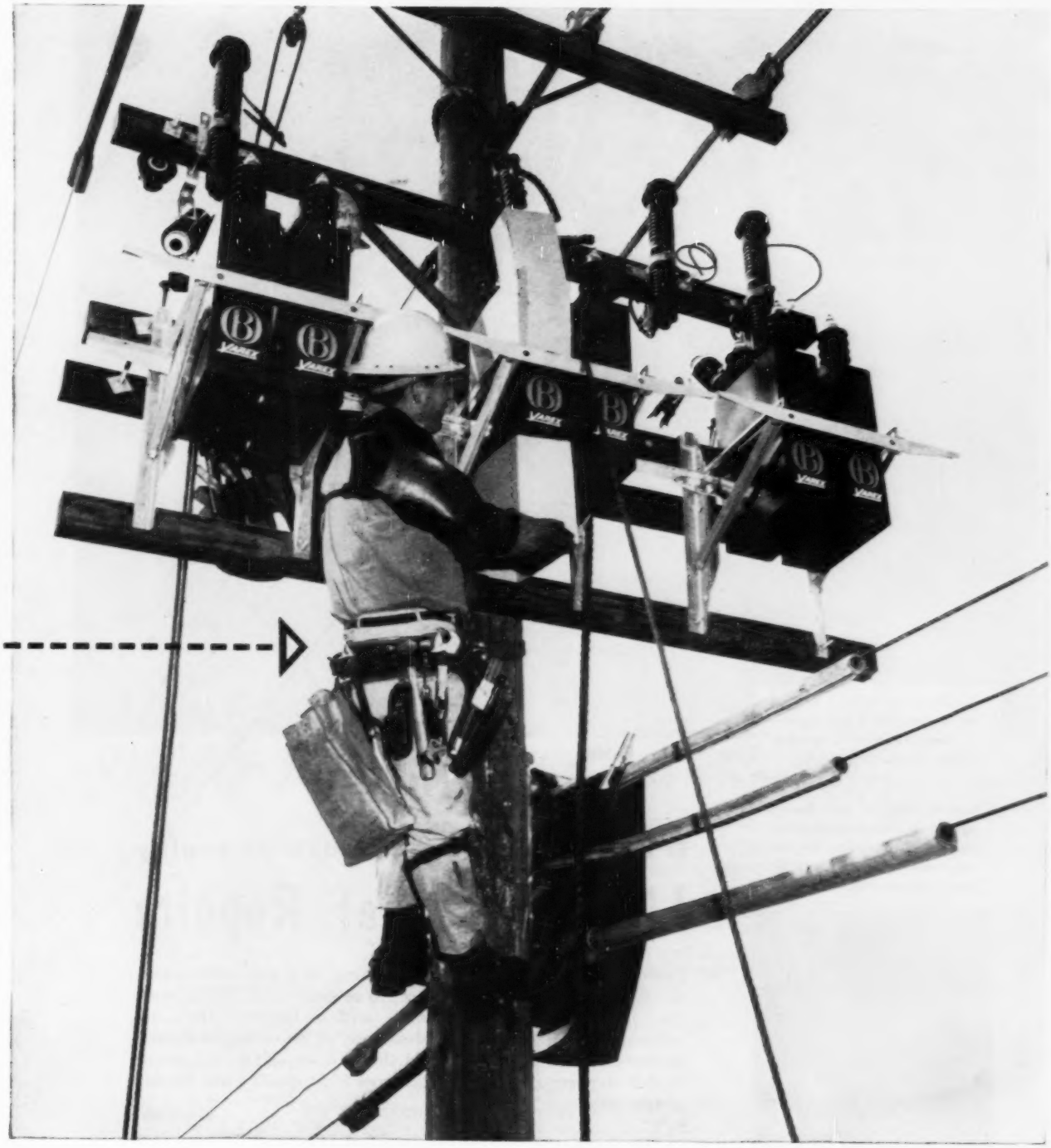
But the real protection is just beginning. For underneath the carton liner is special epoxy-resin finish used on all Varex cases. This is the new finish — available only on Varex—that has been proved superior to other resin base paints on corrosion resistance, abrasion resistance, flexibility and adhesion.

You get this two-way protection with every Varex capacitor — 1) complete protection against weather after the unit is installed; 2) protection against damage in handling right up to the pole top.

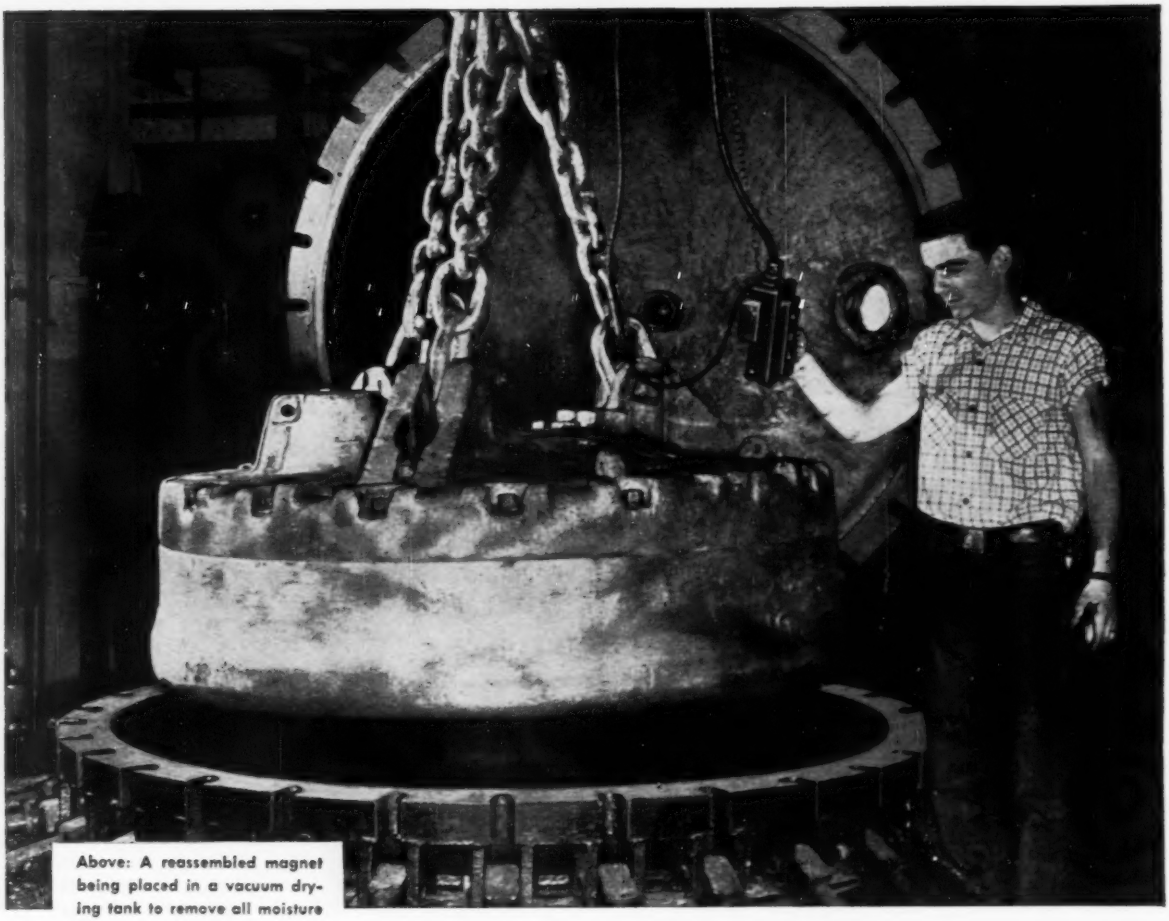
OHIO BRASS COMPANY, MANSFIELD, OHIO

4870-H

For more information circle 27 on reader service card.

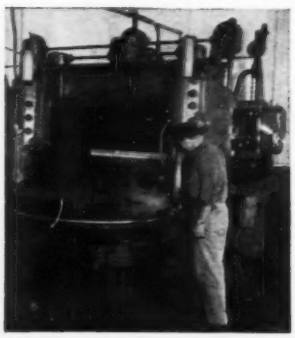


Ohio Brass



Above: A reassembled magnet being placed in a vacuum drying tank to remove all moisture before compounding.

Below: Magnet case being opened on a large capacity boring mill. Capsule-type magnet coils must also be opened by cutting on this mill.



NATIONAL

is equipped for high speed, high quality

Lifting Magnet Repairs

National's lifting magnet department has the equipment, manpower and the "know-how" to restore your lifting magnets to original specifications — and to improve them by redesign which takes full advantage of recently developed techniques and materials. And the new, modern equipment in this department not only insures high quality but speeds production.

For details on what these facilities can mean to you, just call your nearby National field engineer or drop us a line.

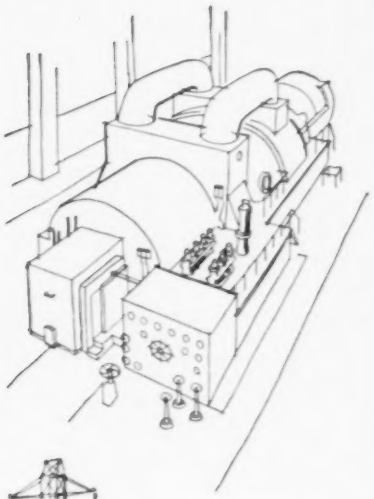
NATIONAL ELECTRIC COIL COMPANY

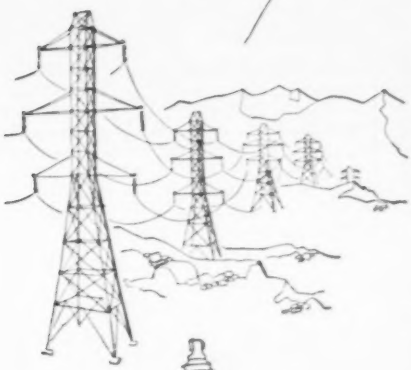
COLUMBUS 16, OHIO, U. S. A.

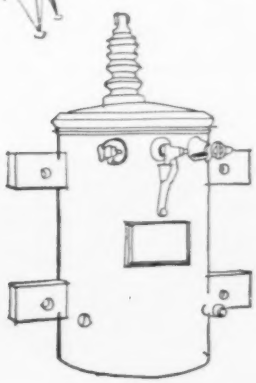
ELECTRICAL ENGINEERS: MAKERS OF ELECTRICAL COILS AND INSULATION—
REDESIGNING AND REPAIRING OF ROTATING ELECTRICAL MACHINES

For more information circle 28 on reader service card.

NOW! more Armco Oriented Electrical Steel to lower costs, improve efficiency of transformers







Production capacity for Armco Oriented grades being expanded to help fulfill demand for these performance-improving electrical steels.

The demand for Armco's Oriented Electrical Steels has exceeded supply ever since their introduction. Now, with expansion of production facilities, you will have added opportunities to utilize their many advantages in the design and production of high quality transformers.

For wound or stacked cores, Armco Oriented Steels, in 12 and 14 mil thicknesses, provide you with this unusual combination of advantages:

1. Lower core loss in the rolling direction.
2. Higher permeability in the rolling direction.
3. Superior lamination factor.
4. Mill-applied permanent insulation.
5. Uniform magnetic properties.

Extensive Design Data Available

To help you make most effective and economical use of these special steels, a 56-page manual on Armco Oriented Electrical Steels has been revised. It contains 40 pages of graphical data on magnetic properties and design information. A copy–Fourth Edition, is yours for the asking.

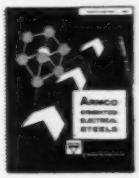
For additional information on the availability of Armco's Oriented Steels and a copy of our design manual, just fill out and mail the coupon.

ARMCO STEEL CORPORATION • 1318 Curtis St., Middletown, Ohio

Send me

☐ Information on the availability of Armco Oriented Steels

☐ A copy of "Armco Oriented Electrical Steels–Fourth Edition • 1957



NAME_____

COMPANY_____

STREET_____

CITY_____ ZONE____ STATE_____

ARMCO STEEL

ARMCO STEEL CORPORATION • 1318 CURTIS STREET, MIDDLETOWN, OHIO

SHEFFIELD DIVISION • ARMCO DRAINAGE & METAL PRODUCTS, INC. • THE ARMCO INTERNATIONAL CORPORATION

For more information circle 29 on reader service card.

WARNING -- Radar Trap!
One way to get a ticket that can't be fixed is to try a high-speed sneak attack past the line of "Texas Tower" radar sentinels now guarding our shores.
When an intruder approaches, his range, bearing, course and speed are instantly flashed to our Air Defense Command, along with voice and intercept command signals. This information, "multiplexed" by Lenkurt single-sideband carrier equipment, rides ashore on a microwave radio beam.
The carrier picked for this application is standard Lenkurt equipment — the same that is in daily use by America's telephone companies. Its adaptability, proved reliability and ease of maintenance have made it the logical first choice for many vital defense installations. It offers frequency economy, saves installation space, provides a maximum number of channels at a minimum unit cost.
To carry forward your own communications projects, join the growing list of commercial and government users who look to Lenkurt for leadership in telecommunications.
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San Carlos, Calif. • Mexico, D.F. • Vancouver, B.C.
Lenkurt products are distributed to public utilities by AUTOMATIC ELECTRIC
For more information circle 30 on reader service card.

New Products

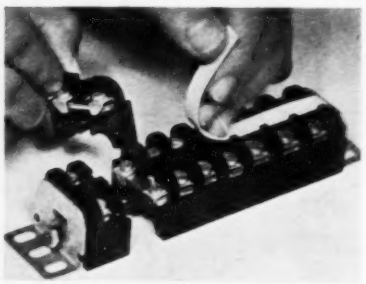
(Continued from page 28A)

surface to be welded. Simultaneously, a condenser discharge spot welder is automatically triggered. The Model *MT809* Rollectrode is compatible with existing condenser discharge type spot welders. Typical installations involve attachment of thermocouples, thermistors, and lead out wires for various electrical devices where adverse environmental conditions, such as shock, extreme temperatures, and high wind velocities exist. For further information contact Micro-Test, Inc., 657 N. Spaulding Ave., Los Angeles 36, Calif. *Circle 205 on the card.*

Type G 30 Ampere Safety Switch. A type *G* horsepower rated, 30-ampere 125- to 250-volt safety switch with easy-to-remove fuses and bakelite block has been announced. Crossbar interference has been eliminated allowing easy removal of plug or cartridge fuses. Switch is single throw, side operated, with visible knife blade construction, 2 or 3 wire. A post is provided to seal handle in OFF position and to padlock cover in closed position. It is used to protect light machinery such as oil burners, water heaters, dryers, lighting and appliance circuits, small motors, etc. For further information call or write J. J. Doyle, Sales Manager, Murray Manufacturing Corp., 1250 Atlantic Ave., Brooklyn 16, N. Y. *Circle 206 on the card.*

Electroplating Racks Spray Coated. Electroplating racks may be quickly and economically insulated against metal plating with Krylon crystal clear spray protective coating. These plating racks are used to hang the pieces to be plated in the plating solution. It takes only minutes to apply and the coated surfaces are quickly dry. Write to Krylon, Inc., 18 W. Airy St., Norristown, Pa. *Circle 207 on the card.*

Terminal Block. A compact terminal block is available for custom assembly or in factory assembled strips rated at 600 volt a-c or d-c, 15-, 25-, and 50-ampere ratings. Unique features incorporated in the design are the snap in marking strip and snap on terminal block, both of which



make modifications to a mounted terminal strip a fast operation. No special mounting rods are required. Standard $\frac{3}{16}$ inch round cold rolled steel fits each molded

(Continued on page 42A)

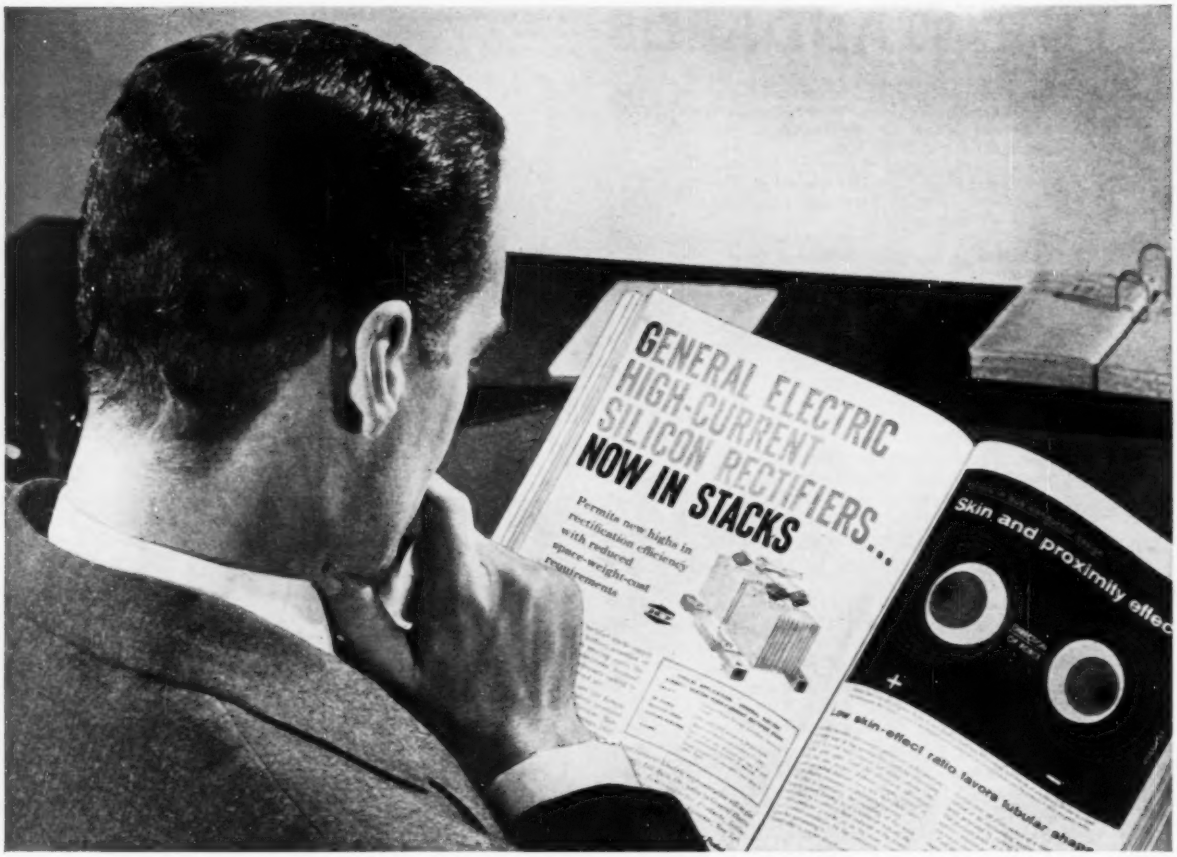
AIEE STANDARDS

Standards on electrical machinery and apparatus chiefly devoted to defining terms, conditions, and limits which characterize behavior, with special reference acceptance tests.

A discount of 50% is allowed to Institute members except as noted. College and bona fide public reference libraries are allowed (except in special cases with † below) a discount of 50% for nonmember prices; dealers and subscription agencies 20%.

1	General Principles Upon Which Temperature Limits are Based in the Rating of Electric Equipment (June 1957)	$0.80
1A	General Principles for Rating of Electric Apparatus for Short-Time Intermittent or Varying Duty (Sept. 1941) (A proposed supplement to No. 1—No charge for copies)	—
1B	Guiding Principles for Specification of Service Conditions in Electrical Standards (May 1944)	.40
1D	Guide for the Preparation of Test Procedures for the Thermal Evaluation of Electrical Insulating Materials (June 1957)	—
1E	Guide for the Preparation of Test Procedures for the Thermal Evaluation of Insulation Systems for Electric Equipment (June 1957)	—
3	Guiding Principles for Selection of Reference Values for Electrical Standards (Oct. 1943)	.60
*4	Measurement of Voltage in Dielectric Tests (Sept. 1953) (ASA C68.1)	.80
*16	Electric Control Apparatus for Land Transportation Vehicles (Oct. 1955) (ASA C48.1)	.60
*17†	Mathematical Symbols (Jan. 1928) (ASA Z10†)	.40
*18	Capacitor Units (Dec. 1951) (ASA C55.1)	.40
*21	Apparatus Bushings (July 1943) (ASA C76.1)	.60
22	Air Switches, Insulator Units and Bus Supports (July 1952)	.80
25	Fuses Above 600 Volts (July 1952)	.80
*28	Lightning Arresters for A-C Power Circuits (Jan. 1957) (ASA C62.1)	.60
*29	Wet Tests (July 1943) (ASA C77.1)	.40
31	Outdoor Coupling Capacitors and Capacitance Potential Devices (Jan. 1944)	.60
32	Neutral Grounding Devices (May 1947)	.80
43	Recommended Practice for Testing Insulation Resistance of Rotating Machinery (April 1950)	.60
45	Recommended Practice for Electric Installations on Shipboard (Mar. 1955)	3.50
48	Potheads (Jan. 1948)	.60
49	Roof, Floor, and Wall Bushings (Jan. 1948)	.60
50	Automatic Circuit Reclosers for A-C Distribution Systems (Jan. 1953)	.60
51	Guiding Principles for Dielectric Tests (6-55)	.60
54	Standard, Test Code, and Recommended Practice for Induction and Dielectric Heating Equipment (Sept. 1955)	.80
55	Guide for Temperature Correlation in the Connection of Insulated Wire & Cables to Electric Equipment (Jan. 1953)	.60
425	Test Code for Transistors	1.20
501	Test Code for Direct-Current Machines (7-57)	.60
503	Test Code for Synchronous Machines (June 1945)	1.40
510	Test Procedure for Evaluation of Systems of Insulating Materials for Random-Wound Electric Machinery (Nov. 1956)	.80
550	Master Test Code for Resistance Measurement (May 1949)	.80
551	Master Test Code for Temperature Measurement (Aug. 1950)	.80
552	Master Test Code for Electrical Measurements in Power Circuits (Nov. 1955)	1.20
600	Specification for Speed Governing of Steam Turbines for Generators (500 kw and Up) (5-49)	.60
{601} {602}	Preferred Standards and Standard Specification Data for Generators for Large 3,600-rpm, 3-Phase, 60-Cycle Condensing Steam Turbine Generators (Jan. 1953)	.60
605	Specification for Speed-Governing of Hydraulic Turbines for Driving Generators (Sept. 1950)	.60
700	Aircraft D-C Apparatus Voltage Ratings (Oct. 1953)	.40
800	Test Code for Direct-Current Aircraft Machines (Jan. 1953)	.80
801	Test Code for Aircraft Circuit Interrupting Devices (July 1954)	.40
**950	Recommended Practice for Measurement of Field Intensity Above 300 Megacycles from Radio-Frequency Industrial, Scientific, and Medical Equipments (Apr. 1952)	.80
**951	Recommended Practice for Minimization of Interference from Radio-Frequency Heating Equipment (May 1950)	.80
**952	Electric Power Distribution for Industrial Plants (Oct. 1956)	3.50
**953	Grounding of Industrial Power Systems (10-56)	1.20
C8.1	Definitions and General Standards for Wire and Cable (Dec. 1944/Oct. 1953) (AIEE 30)	.40
C8.18	Specifications for Weather-Resistant (weatherproof) Wire and Cable (URC Type) (Jan. 1948)	.60
C8.19	Weather-Resistant Saturants & Finishes for Aerial Rubber-Insulated Wire & Cable (Nov. 1939)	.40
C29.1	Insulator Tests (Sept. 1944) (AIEE 41)	.80
C34.1	Pool Cathode Mercury-Arc Power Converters (Jan. 1949)	1.20
C37.1	Relays Associated with Electric Power Apparatus (Mar. 1950)	.60
C37.2	Automatic Station Control, Supervisory & Associated Telemetering Equipments (Oct. 1956)	1.30
C37.4	Alternating-Current Power Circuit Breakers (Dec. 1953)	.60
C37.4a	Apparatus Bushings (Aug. 1954)	†.25
C37.5	Methods for Determining the Rms Value of a Sinusoidal Current Wave and a Normal Frequency Recovery Voltage & for Simplified Calculation of Fault Current (Dec. 1953)	.60
C37.6	Schedules of Preferred Ratings for Power Circuit Breakers (Sept. 1957)	.40
C37.7	Interrupting Rating Factors for Reclosing Service (Aug. 1952)	.30
C37.8	Rated Control Voltages and Their Ranges (8-52)	.30
C37.9	Test Code for Power Circuit Breakers (Dec. 1953)	.60
C37.12	Guide Specifications for A-C Power Circuit Breakers (Aug. 1952)	.60
C37.13	Low-Voltage Air Circuit Breakers (including Application Guide) (Aug. 1954)	.80
C37.14	Test Code for Low-Voltage Air Circuit Breakers (Aug. 1954)	.50
C37.15	Rated Control Voltages & Their Ranges for Low-Voltage Air Circuit Breakers (Aug. 1954)	.30
C37.16	Schedule of Preferred Ratings for Alternating- and Direct-Current Low-Voltage Air Circuit Breakers (10-56)	.30
C37.17	Preferred Pick-Up Calibrations and Trip Delay Settings for Alternating-Current Low-Voltage Air Circuit Breakers (10-56)	.30
C37.20	Switchgear Assemblies and Metal-Enclosed Bus (AIEE No. 27) (Jan. 1955)	.60
C39.1	Electric Indicating Instruments (Panel, Switchboard and Portable Instruments) (Aug. 1955)	2.00
C39.2	Direct-Acting Electric Recording Instruments (Apr. 1953)	†.75
C42	Definitions of Electrical Terms—(Ask for separate folder descriptive of 18 pamphlets on various phases)	—
C50.1	Synchronous Generators, Motors, and Machines in General (Oct. 1955)	1.80
C50.2	A-C Induction Motors, Machines in General, and Universal Motors (Oct. 1955)	1.30
C50.4	D-C Generators, Motors, and Commutating Machines in General (Oct. 1955)	1.50
C50.5	Rotating Exciters for Synchronous Machines (Oct. 1955)	.80
C50.6	Motor-Generator Sets (Oct. 1955)	.50
C50.20	Test Code for Polyphase Induction Motors and Generators (AIEE No. 500) (Dec. 1954)	.80
C57	Transformers, Regulators, and Reactors (including Test Codes and Guides for Operation) (May 1948) and all revised sections issued since basic standard	15.30
Y32.2	Graphical Symbols for Electrical Diagrams (3-54)	†1.25
Y32.9	Graphical Electrical Symbols for Architectural Plans (Feb. 1943) (formerly Z32.9)	.40
Z10.5	Letter Symbols for Electrical Quantities (6-49)	.60
Z24.7	Test Code for Apparatus Noise Measurement (Dec. 1950)	.50
Z32.13	Abbreviations for Use on Drawings (Oct. 1950)	1.00
	Non-member total	$73.25
	Member total	$37.30

* Approved as American Standard.
** A publication approved by the Standards Committee but not as a Standard.



Why 8 out of 10 engineers read the advertising pages of Electrical Engineering

Month after month, the editors of Electrical Engineering ask representative groups of readers to say what sections of the magazine they read and find most helpful in their work.

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1. **NEWS**—about new products, new materials, new designs and new methods
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The advertisers who use the pages of EE to discuss their products and services with you, are there to serve you. They welcome your questions and your requests for information, and for assistance in working out your specific problems. We hope you will continue to keep yourself informed about them—in the advertising sections of Electrical Engineering.

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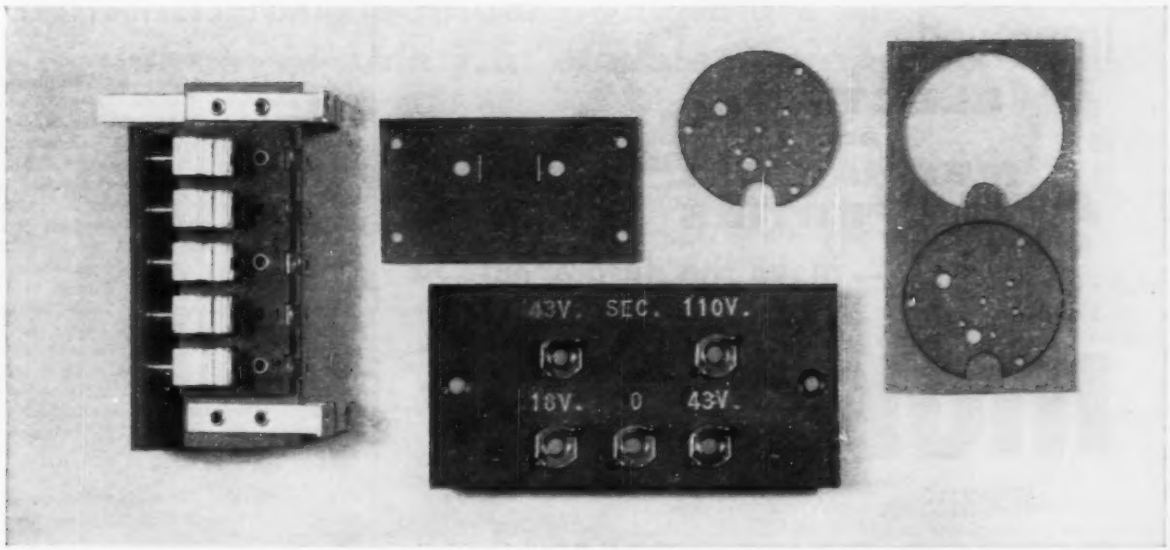

LEADING MANUFACTURERS USE VULCOID. For a punched timer-switch part that operates in oil; for arc chutes in circuit breakers; for the insulation and structural part of an auto-headlight dimmer switch; for a formed electrical switch part carrying 110-volt 60-cycle current; for a mass-produced, 110-volt light-socket part—for these and many more Underwriters-approved parts, CDF Vulcoid is an effective, economical insulation material—good where neither plain fibre nor plain phenolic laminate would suffice.

Fibre gives it high arc-resistance . . .
Aniline resin gives it moisture-resistance

CDF VULCOID

resin-impregnated vulcanized fibre

Vulcoid® is *different.* To the electrical properties of vulcanized fibre we've added the low moisture-absorption of an aniline-type resin with an unusual affinity for cellulose fibers—*all at low cost.* Excellent moisture-resistance (two to four times that of plain vulcanized fibre) helps stabilize Vulcoid's excellent electrical insulating characteristics. Its low cost makes Vulcoid a fine production material for applications of moderate electrical requirements.

Underwriters' approval. Vulcoid is approved by Underwriters' Laboratories as a material for the insulation of current-carrying parts in electrical equipment. It carries the distinctive red and blue thread marking of such materials.

Easy to work. Like vulcanized fibre, Vulcoid is readily drawn or formed into permanent shapes, punched, machined (see illustration above) at low cost. CDF fabrication facilities can give you production quantities of Vulcoid parts to your specifications.

Learn all the advantages of designing around low-cost CDF Vulcoid parts such as arc-deflector spacers, transformer and motor lead bushings, circuit-breaker and transformer barriers, knife-switch guides, transformer coil separators, instrument and contact panels, baseboard receptacles, etc. Ask your CDF man or write for new technical bulletin.

CONTINENTAL-DIAMOND FIBRE

A SUBSIDIARY OF THE Budd COMPANY • NEWARK 86, DEL.

COMPARATIVE PROPERTIES

Property	Commercial Vulcanized Fibre 1/16"	Paper Base (XX) Phenolic 1/16"	VULCOID 1/16"	1/8"	1/4"	1/2"	3/4"	1"
Arc Resistance, seconds	140	4	110	110	110	110	110	110
Specific Gravity	1.25	1.35	1.35	1.35	1.35	1.30	1.20	1.10
Moisture Absorption, % 24 hours	60	1.4	30	15	6	4	4	4 8
Tensile Strength, thousands of psi. —MD CD	11	12 10	12.5 7.5	12 7.5	11 7	9 6.5	8.5 6	5.5 12
Flexural Strength, thousands of psi. —MD CD	16	19 17	24 19	23 17	20 16	16 13	14 11	9 60
Shearing Strength, thousands of psi. —MD CD	8.5 8	14 12	14 12	12.5 11	12 10			
Compressive Strength, flatwise thousands of psi.	25	34	36	36	36			
Izod Impact Strength (Edgewise) Ft. lbs. per inch of notch MD	2.0	0.50*	1.2	1.2	1.2	1.2		
Dielectric Strength, Perpendicular to surface VPM	175	700	475	425	275	170	100	

NOTE: ASTM test methods used for Specific Gravity, Moisture Absorption, Arc Resistance, Tensile, Flexural, Compressive, and Dielectric Strength.

For more information circle 32 on reader service card.

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ELECTRICAL and MECHANICAL PROPERTIES
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BETTER PERFORMANCE
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Motor and Generator Brushes
Morganite brushes enjoy a reputation world-wide for trouble-free service. Available for fractional horsepower, aircraft, automotive, traction and industrial applications.

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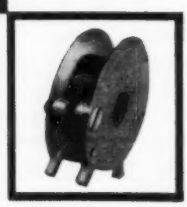
Assure high efficiency brush operation by maintaining positive contact between the brush and the commutator or ring. Standard types include cantilever radial, radial, trailing, reaction and AC slip ring holders.

Electrical Contacts
Including drum controllers, contactors and starters. Incorporate metals in a refractory carbon base for improved electrical conductivity and mechanical strength. Contacts are self-lubricating, non-welding.



Carbon Current Collectors
Reduce operating costs on travelling cranes. Cost less, wear longer and reduce conductor wear to a minimum. Will not blister or rough conductor, afford trouble-free service over extremely long periods.

Complete Catalogs Available — call or write today. Recommendations on specific applications supplied promptly on request.

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Manufacturers of Fine Carbon Graphite Products including Carbon Specialties, Motor and Generator Brushes, Carbon Piles, Current Collectors and Electrical Contacts
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For more information circle 43 on reader service card.

TRADE LITERATURE

Communications "Red Book." A new edition of "Specifications for Municipal Communications Control, Signal and Power Cables" has been published. Known popularly among municipal engineers as the Red Book of the International Municipal Signal Association (I.M.S.A.), it includes the latest specifications for police communications, traffic and fire alarm systems as approved by I.M.S.A. In addition, Kaiser Aluminum approved specifications are included for 300-volt Laytex resin cables, 600-volt laytex resin cables of the I.M.S.A. type, and 300-volt Laytex resin cables. The new Red Book, an up-to-date version of the 1951 edition, may be obtained free from R. H. Turner, Electrical Conductor Division, Kaiser Aluminum & Chemical Sales, Inc., 919 N. Michigan Ave., Chicago 11, Ill.

PVC Pipe Catalog. Dielectric values, power factor, and volume resistivity of Byers PVC (polyvinyl chloride) pipe along with mechanical and thermal properties are explained in the first edition of a 30-page catalog recently published by the company. It describes the general characteristics of PVC pipe, its properties and applications, and gives installation data. The catalog is available upon request to Engineering Service Department, A. M. Byers Company, Clark Building, Pittsburgh, Pa.

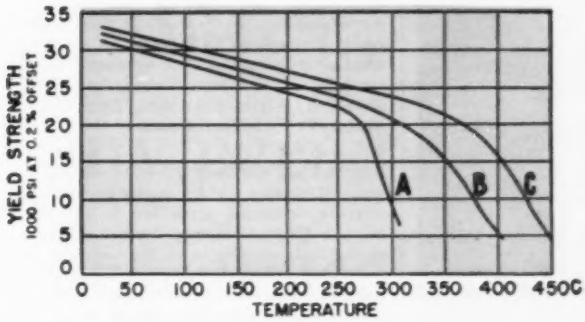
Transistor Index. A unique transistor index has been introduced by Zeus Engineering Corporation to facilitate selection of the optimum transistor for a given application. This method utilizes punched cards which contain pertinent transistor data. Transistor selection is rapidly obtained by manual needle sorting on the basis of desired parameters. Thus, no machinery of any kind is required. This method eliminates the frustration of searching through volumes of data sheets. It also provides a compact central transistor file. For further information, write to: Zeus Engineering Corporation, 635 South Kenmore, Los Angeles 6, Calif.

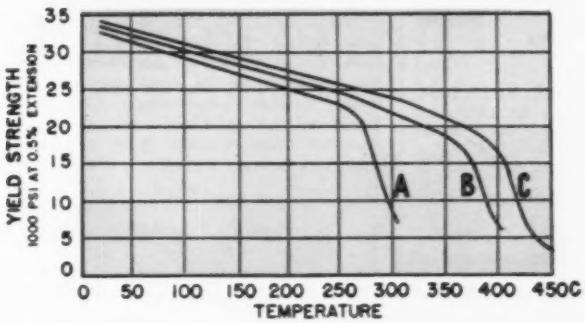
Mill Products Brochure. A technical brochure featuring mill products and alloys produced by Harvey Aluminum has been published. "Mill Products and Alloys," the 12-page technical brochure, reviews in detail mill products in aluminum, titanium, and other metals, covering a full range of shapes, sizes, and alloys. The booklet is of significant value and interest to designers, engineers, purchasing agents, production men, and metallurgists. Copies can be obtained free by writing to Harvey Aluminum, 19200 S. Western Ave., Torrance, Calif.

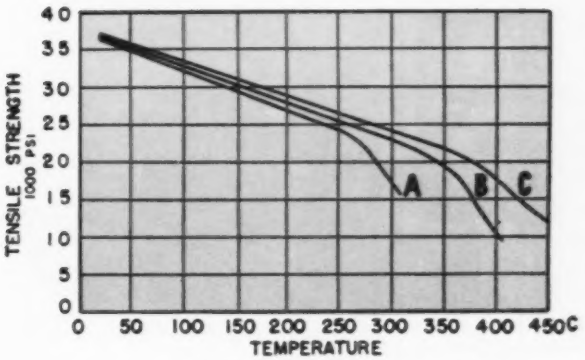
Transformers Catalog. A 16-page, 2-color catalog for a new line of single phase, 15,000-volts and below, 167-kva and below, type *OS* distribution transformers has been published and can be obtained by writing to H. K. Porter Company, Inc., Delta-Star Electric Division, 17th and Cambria Sts., Philadelphia 32, Pa.

(Continued on page 56A)

How to give electrical conductors an improved margin of safety at elevated temperatures







A. Silver content normal
B. Silver 8.7 ounces per ton
C. Silver 28. ounces per ton

Copper strips cold rolled,	0.050 ins. gage
Time to heat, approximately	1¼ hours
Time of test at heat, approximately	¼ hour
Speed, testing machine head,	0.01 ins. per min.

American Brass Company Metallurgical Research Laboratory 1954

Tests show influence of silver on tensile properties of high-conductivity copper at elevated temperatures

Silver-bearing copper is used extensively in windings, collector rings, and commutators of motors and generators, in order to retain structural strength at elevated temperatures during assembly and operation.

There are now many other places where electrical conductors must stand up under temperatures well above those heretofore considered normal.

The amount of silver needed to meet a particular set of conditions, however, has until recently been difficult to determine. At the left are charts summarizing the results of tests made in The American Brass Company Metallurgical Research Laboratory, which can help serve as a more precise guide.

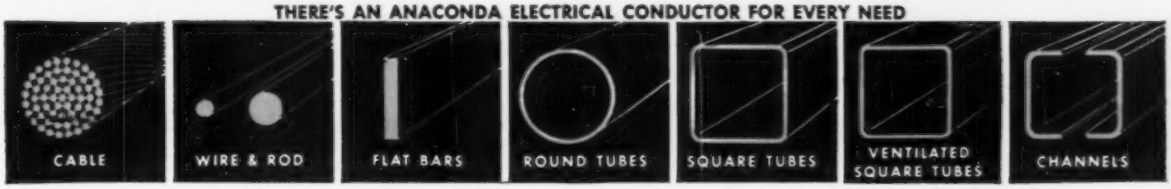
The curves for the yield strengths at 0.2 per cent offset and 0.5 per cent extension are significant to electrical engineers with problems involving the operation of conductors at elevated temperatures, for these values are indices of the limits of elastic behavior. The drop in absolute values of the tensile properties of all three coppers with rising temperature, however, should be noted and be allowed for in the selection of shape and size of conductors that are expected to run hot.

For more complete information on the effect of temperature on the mechanical and electrical properties of copper, send for a copy of Publication C-25, "Anaconda Copper for Electrical Conductors." This 62-page book also has a wealth of other general information, plus convenient new tables to help you in the selection of rigid bus conductors.

Technical Service. The assistance of Anaconda specialists in the selection of conductors to meet your special problems is available to you. For such assistance—or to get a copy of "Anaconda Copper for Electrical Conductors"—see your nearby Anaconda representative. Or write: The American Brass Company, Waterbury 20, Conn. 57108

ANACONDA®
COPPER CONDUCTORS
Made by The American Brass Company

THERE'S AN ANACONDA ELECTRICAL CONDUCTOR FOR EVERY NEED



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Electrode of only 1-inch length permits non-destructive fault detection at production rates to 4000 fpm

MODEL 10 CVX

This High Voltage DC Insulation Tester is ideal for use with extruders, vulcanizers or twinners. May be used to replace AC sparkers where 0-10KV DC is ample (20KV models also available).

Accurate, efficient detection, indication and recording of every fault is assured, without burning or marking insulation. Safe and easy operation by unskilled personnel. "Zero-length" electrodes (1" and shorter!) conserve floor space. Supervisory circuits and sectionalized construction facilitate servicing.

For complete technical data, write TODAY to:

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For Missile Testing

and general use

30 to 300 Amps

- Closely Regulated
- Fast Response
- Underwriters Approved
- Rigid Quality Control

CHRISTIE

SILICON POWER RECTIFIERS

Available in Industrial and Military types. Military type meets specs MIL-E-4970 and MIL-I-6181. Other stationary and mobile styles available up to 1500 Amps.

Write for Bulletin AC-58-A

CHRISTIE ELECTRIC CORP.

Dept. EE, 3410 W. 67th St., Los Angeles 43

Over a Quarter Century of Rectifier Manufacturing

Circle 35 on the card.

BIBLIOGRAPHY ON WATTHOUR METERS

November 1957

Publication S-100 is a bibliography of approximately 1,000 references of standards, text books, and periodicals. The 63-page compilation was assembled by members of the AIEE Subcommittee on Watthour Meters of the AIEE Indicating and Integrating Instruments Committee, assisted by G. A. Palmer representing EII and AEIC. The price is $3.00. Request from the Order Department.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS,
33 West 39th Street,
New York 18, N. Y.

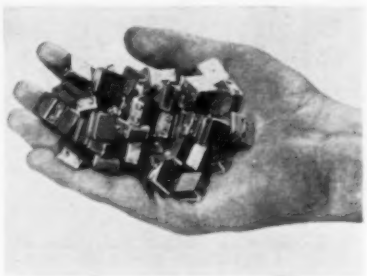
New Products

(Continued from page 36A)

piece and permits rapid assembly of special requirements. All three current ratings can be assembled into one mounting strip. Open type terminals and pan head screws which have captive wire clamps make wiring easy. The pleasing appearance adds quality to any product. Write for Bulletin 457, Gemco Electric Company, 25685 W. Eight Mile Rd., Detroit 40, Mich. *Circle 208 on the card.*

Alpeth-Type Cables. Production of Ankoseal Alpeth-type cables is geared for immediate deliveries, according to Ansonia Wire & Cable Company. Newest product in the Ankoseal line of cables, the Alpeth-type innovation is shielded with low-resistance corrugated aluminum, longitudinally applied, which is said to assure greatly improved lightning protection and to reduce induction noise to a minimum. Conductors are fully color coded, and all pairs are guaranteed. The outer jacket and insulation of the conductors are of tough durable polyethylene. Complete details on Ankoseal Alpeth-type cables are available from Ansonia Wire & Cable Company, Ashton, R. I. *Circle 209 on the card.*

Tiny Microphone. A special microphone so small that a hundred can fit in the palm of one hand has been developed. This miniature acoustic device gives high-quality performance and is said to be exceptionally rugged and dependable despite the fact that it is only a half inch square and little more than a quarter inch thick.

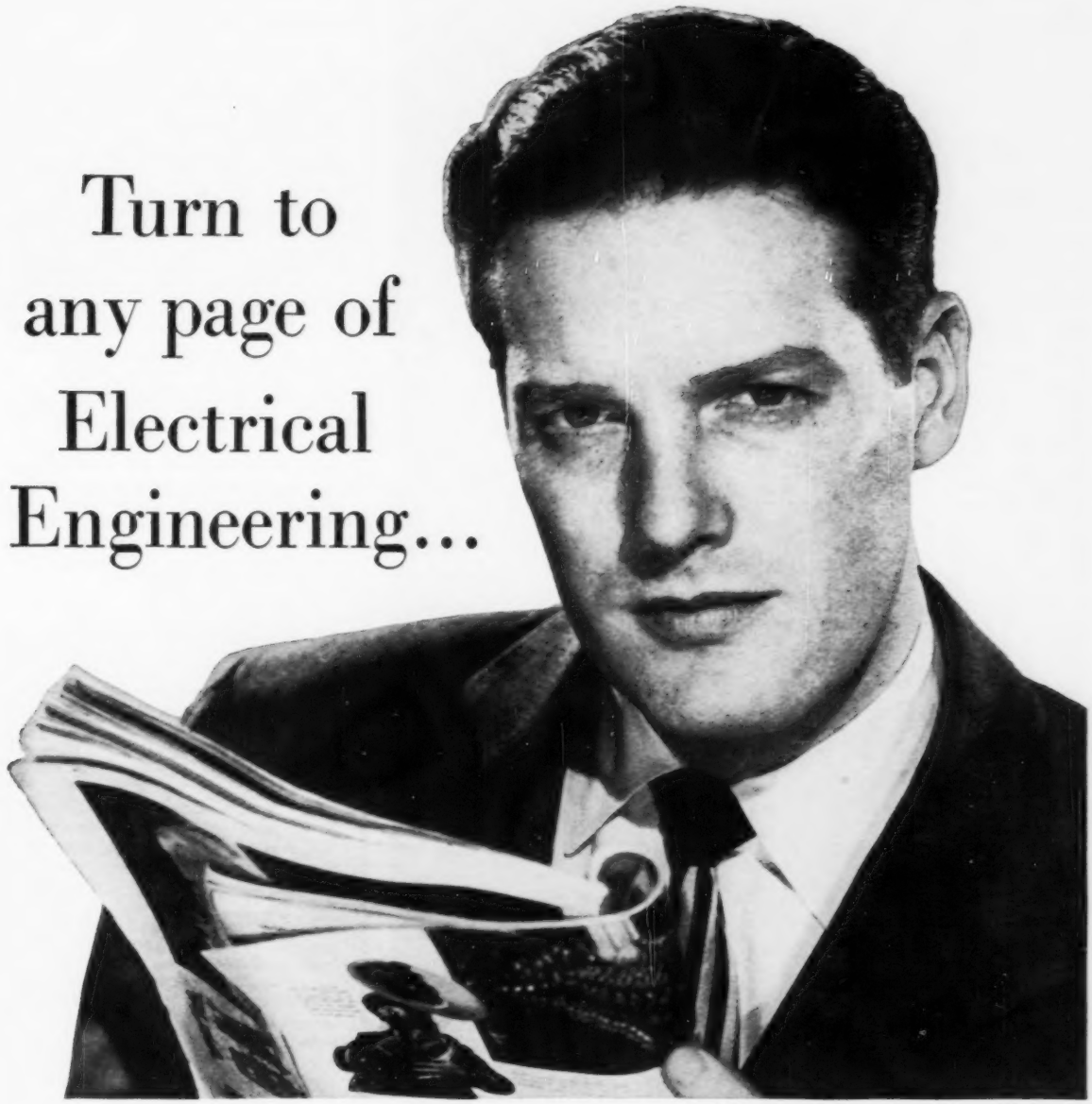


The *MC30* microphone was designed for use by manufacturers of hearing aids, tape recorders, and dictating equipment. It weighs less than one sixth of an ounce and is of the controlled magnetic type. Response rating is from 400 to 4,200 cycles per second; output is −76 db at 1,000 cps, and impedance is 2,000 ohms at 1 kc. Write to Shure Brothers, Inc., 222 Hartrey Ave., Evanston, Ill. *Circle 210 on the card.*

High-Corona Level Coaxial Cable Assemblies Connectors. A new series of connectors for coaxial cable assemblies are now available from H. H. Buggie, Inc., Box 817, Toledo 1, Ohio. Designed for a wide variety of electronic, industrial, and military applications, these high-voltage coaxial connectors have a rated

(Continued on page 44A)

Turn to any page of Electrical Engineering...



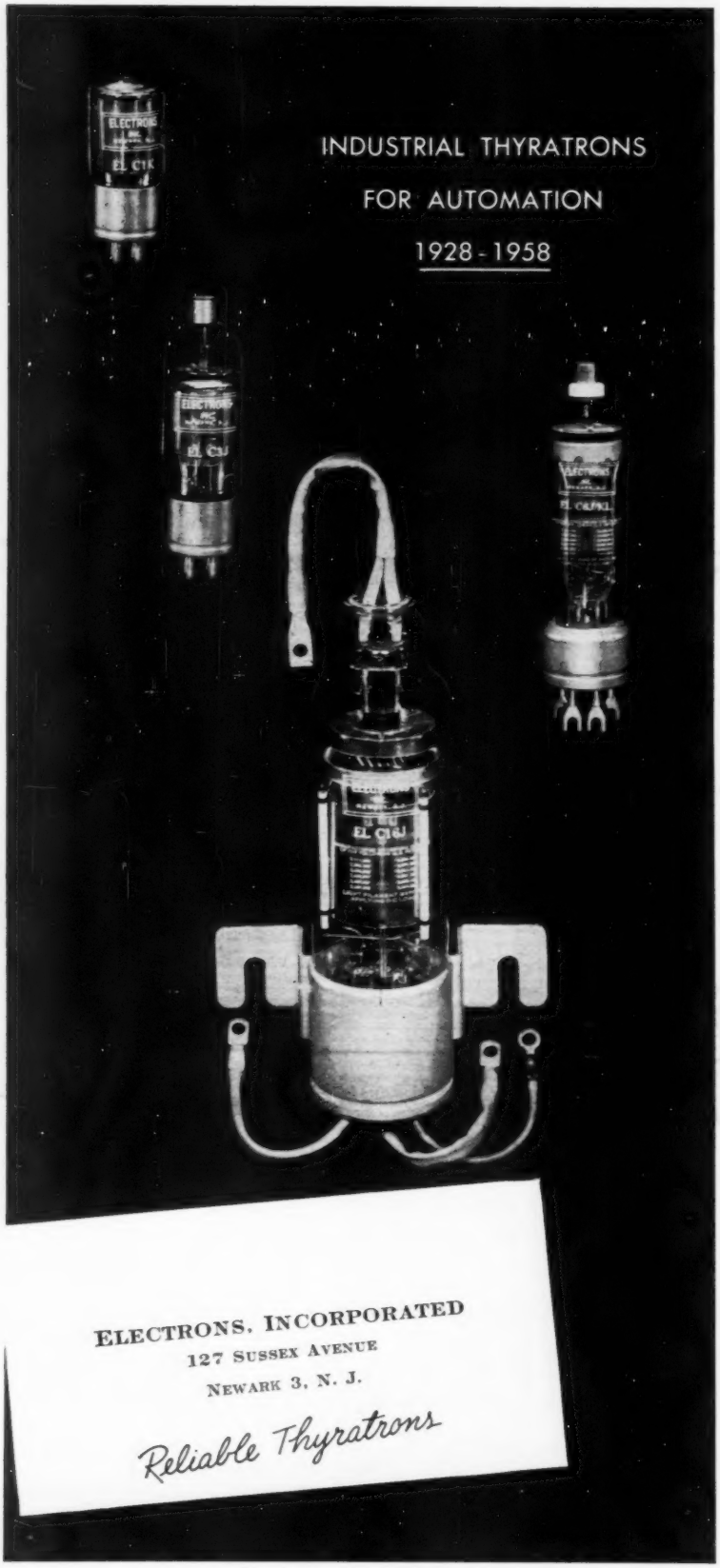
Closely related to EE's broad editorial coverage of news and factual information of the technological aspects of the industry—are the advertising messages appearing in its pages, monthly.

This advertising is designed to keep you informed—of product improvements and design, of the applications and use of apparatus and equipment, of the development of materials and components essential to your production.

And for those responsible for construction and installation – to point the way to lower costs and to short-cuts that help speed the job.

In short, advertising which appears in EE is contributing to your economic, technological and business progress. It will profit you to read it—with the same care and attention you give to the carefully compiled editorial pages of EE.

It will pay you to read advertising regularly in **ELECTRICAL ENGINEERING**
. . . the electrical engineers own magazine



For more information circle 36 on reader service card.

New Products

(Continued from page 42A)

corona level exceeding 15 kv a-c. Size-for-size they also have higher voltage handling capacities than comparable designs. Write to the company for further information. *Circle 211 on the card.*

Flashlight—Continuity Checker. A continuity checker designed as a flashlight has been made available. It can be used as a flashlight or a circuit tester. Regular flashlight batteries will provide sufficient power for the testing of electrical circuits, fuses, cords, low voltage lamps, motor windings, coils, and other such electrical components. It comes with a removable test lead 30 inches long that plugs into place quickly and easily. The other end is equipped with two alligator clips that provide simplified testing. Dead circuits can be tested with the test leads, and the flashlight makes it an even more handy means of searching the dark recesses of electrical equipment. For further information write direct to the Sittler Corporation, 18 North Ada St., Chicago 7, Ill. *Circle 212 on the card.*

Versatile Strip Chart Recorders. A 3-position pen, a pen jogger, an events marker pen, a curve follower pen, and an access door, all of which are designed for the fuller utilization of strip chart recorders, recenty have been developed by Royson Engineering, 100 N. Penn. St., Hatboro, Pa. The 3-position pen, which is affixed to the side of the recorder, writes on the margin of the chart and is said to be particularly useful for recording the output of an integrator. The jogger, which is useful in testing-machine work to identify the knee of the curve, is an attachment for the pen carriage and it contains a solenoid which, when energized, causes the pen to make a vertical pip that is easily identifiable. The events marker pen, either two or three position, is designed to be mounted on the door frame of recorders on which no other space is available. The curve follower pen, which easily clips on the follower index, is useful in producing a proved record on the Brown-Royson curve follower. The access door is used when it may be desirable to keep the door locked while permitting the writing of notes on the chart itself. For full details, write to the company. *Circle 213 on the card.*

Direct Reading Caliper. Much of the time and effort normally required for measuring parts and materials is saved by the use of this direct reading caliper. It not only measures bar stock, sheet stock, and lathe turnings up to 4-inch thicknesses, but also measures castings and moldings of irregular shapes that are difficult to size at all by other methods. Squeezing the handle opens the caliper; a spring closes it gently on the work. Then the size is read directly on a 0- to 4-inch, black-on-white scale that is precisely calibrated in inches by 32nd's. Write to Master Specialty Co., Inc., 3725 Monitor Ave., Minneapolis 26, Minn. *Circle 214 on the card.*

(Continued on page 46A)

No. 1 in a series

Right off the Wire

An all-electronic telephone exchange (said to be the first for commercial use) has no moving parts, is noiseless and can be used in explosive atmospheres. It includes a "memory" which will hold an incoming call.

Wire can be strung beside a railroad track by a new travelling crane at the rate of 60,000 feet per hour.

Simplex recently completed one of the largest and heaviest shipments of cable ever transported on one reel — nearly two miles of ANHYDREX XX insulated submarine cable weighing 60 tons.

A new rubber-like material is porous, but will contain liquids.

Boron, lithium, hydrogen peroxide and fluorine compounds are to be the fuels of a new bomber reported to be in the design stage.

Smog-causing chemicals from automobile exhausts can be eliminated by a chemical catalyst developed by an automobile manufacturer.

Improvements in the explosive rivet have made it noiseless.

Only the touch of a hand is needed to light a new lamp. The electricity in the hand does the work.

Thorium is about three times as plentiful as uranium. A new process for the production of reactor-grade thorium should lead to a reduction in the cost of atomic fuel.

A high-output ultraviolet lamp, for heating and air-conditioning ducts, is claimed to be 1,000 times more effective in killing viruses and bacteria than an equal amount of radiation from the sun.

The world's largest solar furnace is to be completed in 1959. It will produce temperatures as high as 8,000°F, which is about 70% of the temperature of the sun's surface.

An ultra-hard glass has been developed that retains its hardness up to 1508°F.

The cost of converting sea water to fresh water has been reduced from $1.50 to 60 cents per thousand gallons.

"Talk-back TV", a new advance in educational television, enables a pupil to ask questions of a teacher who is broadcasting from a distant room.

Scientists have been able to produce shock waves with speeds of more than 100,000 mph (above Mach 150) involving temperatures higher than 100,000°F.

Some 1958 automobiles are using aluminum instead of copper in battery cables.

The first deep sea telephone cables to utilize the revolutionary new Bell Laboratory vacuum tube repeaters were manufactured by Simplex. Minimum tube life is expected to be 20 years.

Danish trawlers are using nylon propellers. The four-foot, three-bladed size weighs only seventeen pounds and they reduce vibration, resist impact damage and corrosion.

A cell that generates electricity by the chemical action of oxygen and hydrogen has been announced. It avoids some of the disadvantages of both dry cells and storage batteries.

An airplane has been built which can change its shape while in flight for the purpose of testing aerodynamic configurations.

C-L-X (Sealex) is the name of a new, completely sealed, corrugated metallic cable sheath manufactured by Simplex. It is pliable, moistureproof, and permits cable engineers to select the most economical cable cores, while assuring the greatest mechanical protection available.

Observations of the aurora during the Geophysical Year show that it occurs simultaneously at both the North and South Poles. This definitely identifies it with the earth's magnetic field.

A miniature battery about the size of a paper clip is said to deliver a steady flow of current for 176,000 hours.

Shirtsleeve Service

Simplex recently completed an order for 4600 ft. of Anhydrex XX Parkway Cable. The Simplex man was on the spot to help with installation, which happened to be on a 9,500 ft. mountain in rough terrain. He helped design a reel mounting bracket (for holding up to 7200 lbs.) for the front of the tractor used for laying. He supervised the laying of two lengths 2200 feet long.

This case typifies the kind of cooperation that Simplex offers in order to assure correct installation and satisfactory service.

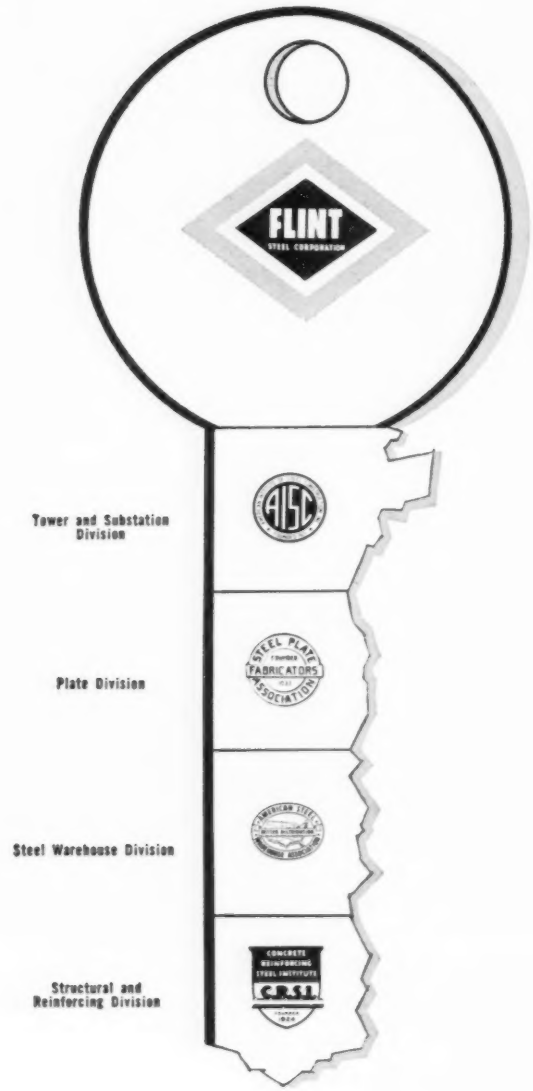
SIMPLEX WIRE & CABLE CO.
Cambridge, Massachusetts and
Newington, New Hampshire

Simplex

Highest quality cables for: Mining · Power & Lighting · Construction · Transportation · Communications · Signalling

See us at Booth 1124 Plant Maintenance & Engineering Show, Chicago

For more information circle 37 on reader service card.



The key to successful bidding and a source for steel fabricated to your most exact specifications could be any one or all four of Flint's divisions — Structural and Reinforcing — Tower and Substation — Plate Products and Steel Warehouse.

Some clients take advantage of all FOUR DIVISIONS, others one or more.

for over 40 years

FLINT STEEL CORPORATION

TULSA . . . MEMPHIS

For more information circle 38 on reader service card.

New Products

(*Continued from page 44A*)

Container Heating Element. A Wrap-It-Heet *PH-5* container heating element designed for industrial plants, small shops, and workrooms, has been announced by the Acra Electric Corporation. This heating element is for use on standard 5-gallon straight side steel pails or containers which are approximately $11\frac{1}{4}$ inches in diameter. It is used to heat or melt waxes, resins, adhesives, feed mixtures, oils, and nonvolatile chemicals which require heating to facilitate melting or removal from the container. Model *PH-5* is rated 1, 250 watts at 115 volts, and is suitable for a-c or d-c operation. For complete information, write W. H. Knoepfle, Acra Electric Corp., 9909 Pacific Ave., Franklin Park, Ill. *Circle 215 on the card.*

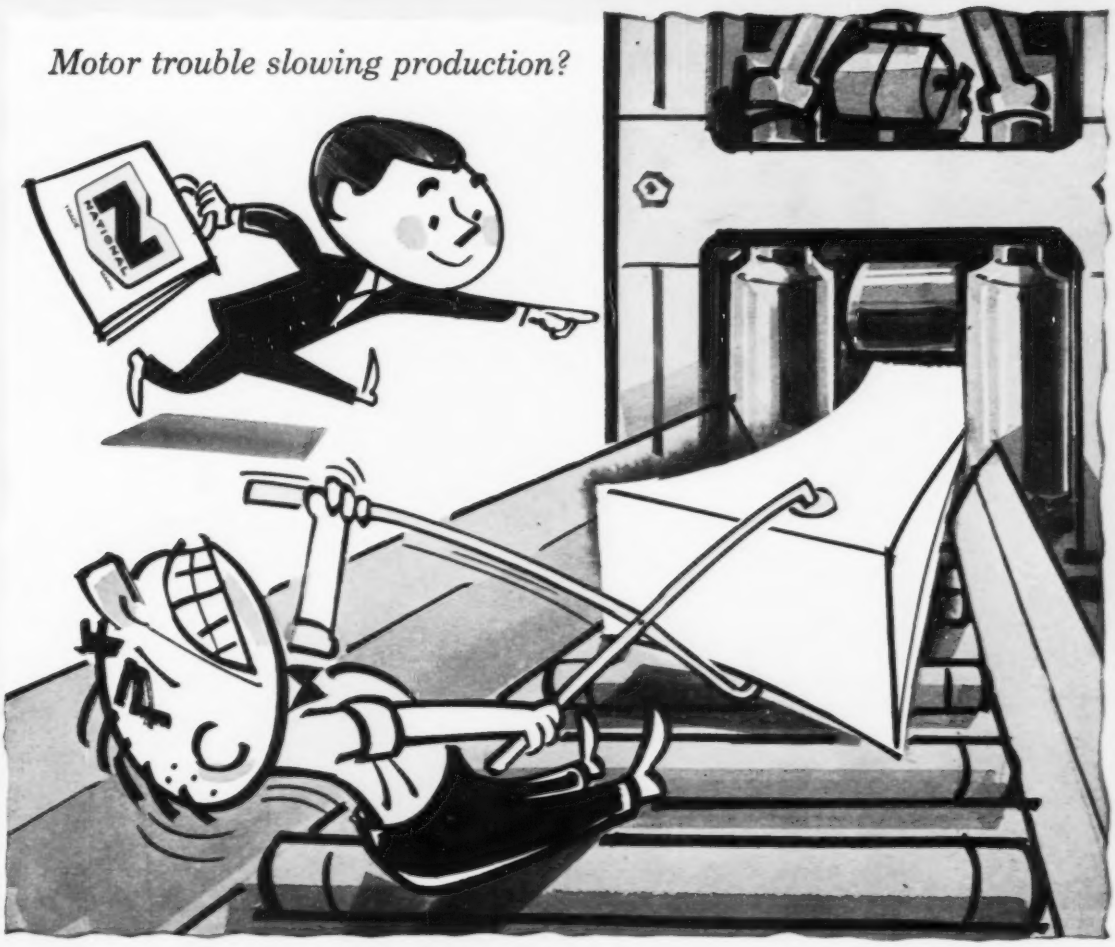
Inert Gas Welding Unit. A *TIG* welding attachment for factory installation only on Hobart motor generator arc welders has been announced by Hobart Brothers Co. The unit is designed for critical *TIG* welding applications where extremely low ripple, 1% to 2%, d-c welding current is required to weld such metals as stainless steel, high carbon steel, cast iron, silicon bronze, deoxidized copper, and silver. The high frequency unit, complete with gas and water valves, is neatly mounted at the left of the welder control panel. Write to Hobart Brothers Co., Hobart Square, Troy, Ohio. *Circle 216 on the card.*

Ferroxcube Memory Core. The availability of a new ferrite memory core designated as *M-2* is announced. Of special interest to manufacturers of computer equipment, this tiny toroid core measures only 0.075-inch OD by 0.048-inch ID by 0.022-inch thick. These fully tested memory cores operate at 670 milliamperes full current and have a switching time of less than 1.5 microseconds. They are immediately available. Additional information and specifications are available from the Applications Engineering Department, Ferroxcube Corporation of America (a subsidiary of North American Philips Co., Inc.), 50 E. Bridge St., Saugerties, N. Y. *Circle 217 on the card.*

Fool-Proof Electronic Burglar Alarm. Development of the "Electro-Sentry," a compact, electronic alarm and control system, for use in either home, office, retail establishment, or industry has been announced by Gulton Industries, Inc., 212 Durham Ave., Metuchen, N. J. It protects all possible points of entry simultaneously. This is accomplished by a three-dimensional pattern of protection to which height and depth have been added to the standards, length and width. Homes protected by this new appliance cannot be entered without tripping the alarm. Prowlers are detected before they can attempt entry, setting off the alarm or flooding the area with light just by their approach. Thus, it is not possible to cut the wires, jam, or jump the signal until the alarm has been sounded. As a burglar alarm, the

(*Continued on page 50A*)

Motor trouble slowing production?



Your NATIONAL brush man helped solve this slowdown problem!

JOHN BEHEN

Motor trouble at this 44″ steel mill caused one costly slowdown after another, says "National" Carbon Brush Man, John Behen. Source of the production trouble – excessive film build-up on one of the mill's edger motors.

The mill tried several brushes to alleviate this condition but with no success. They called in John Behen who analyzed the operation and recommended the proper "National" brush grade. *Result:* a 100 ton increase in daily production thanks to trouble-free motor performance. Incidentally, John went on to solve similiar brush problems on 3 of the steel mill's 5,000 amp motor-generator units.

John Behen and his fellow "National" Carbon Brush Men have been solving industrial brush problems for years. Their experience and training – backed by "National" *long term brush development* – make them the logical consultants on any industrial brush problem.

Call your "National" Carbon Brush Man today. Or write National Carbon Company, Division of Union Carbide Corporation, 30 E. 42nd St., New York 17, N.Y.

The terms "National", "N" and Shield Device, and "Union Carbide" are registered trade-marks of Union Carbide Corporation

UNION CARBIDE

NATIONAL CARBON COMPANY • Division of Union Carbide Corporation • 30 East 42nd Street, New York 17, N. Y.

Sales Offices: Atlanta, Chicago, Dallas, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco. *In Canada:* Union Carbide Canada Limited, Toronto.

For more information circle 39 on reader service card.

MOLDED CASE CIRCUIT BREAKERS

I-T-E magnetic trip Type ETI circuit breakers provide readily accessible trip adjustment.

FOR MOTOR APPLICATIONS... ETI BREAKERS INSURE BETTER PROTECTION

Type ETI magnetic trip circuit breakers employ specially designed overload devices to provide pinpoint, instantaneous short-circuit protection. When used in conjunction with motor protective relays, Type ETI molded case circuit breakers represent the ultimate in motor protection.

A new, informative booklet—yours for the asking—explains in detail why Type ETI molded case circuit breakers insure better protection.

As manufacturers of all types of circuit breakers—and the manufacturers of industry's most complete line of molded case breakers—I-T-E offers this booklet as a service to the electrical industry. Small Air Circuit Breaker Division, 19th & Hamilton Sts., Phila. 30, Pa.

WRITE TODAY FOR THIS NEW BOOKLET

Please send me your new booklet "TYPE ETI MOLDED CASE CIRCUIT BREAKERS FOR MOTOR CIRCUITS"

Name _____

Company _____

Address _____

City _____ Zone _____ State _____

I-T-E CIRCUIT BREAKER COMPANY
PHILADELPHIA, PENNSYLVANIA

H. J. Reichel

are you fighting SPACE?

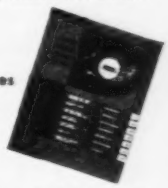
No need to suffer from engineering claustrophobia, if you design with CANNON PLUGS in mind!

Coaxials. Screw-type coupling Low VSWR. for 50-, 70-, 93-ohm cable
K miniatures 3 to 50 contacts 13 different arrangements
DP Type Rack-Panel-chassis style 2 to 5 contacts
MC Sub-Miniatures 3, 6, 12 contacts Built for rugged use
D Sub-Miniatures 9 to 50 contacts Same space . . . same weight!

Cannon Miniature and Sub-Miniature Plugs are rugged, easy mating, unusually versatile, neat and compact. When you design with Cannon Miniatures in mind you'll get complete electrical circuit dependability in a very small space. Up to 50 contacts in ½ or ⅓ the area taken by standard multi-contact connectors!

Rectangular and circular types. Hermetically sealed, vibration and moisture resistant, and general purpose designs. Contacts for 5, 10, 15, 25 amps . . . and miniature coaxial connectors. Practically all five ampere contacts are gold plated. High dielectric insulation in phenolics, resilient materials, glass seals, Zytel, Diallyl Phthalate and Melamine. Aluminum alloy or steel shells, depending upon application.

Miniature lines include: DPA, DPX, DPM, DPG, K, MM, MR and Diamond MB and SM Coaxial connectors. **Sub-miniatures:** D, MC, and Diamond DIC Coaxial connectors.



Write TODAY for new 32-page 2-color Miniatures Bulletin HMC-2. Also, write for Bulletin SM-1, "Soldering Small Contacts."

For an interesting discussion of the broad subject of "Reliability," write for Cannon Bulletin R-1.

CANNON PLUGS

WHERE RELIABILITY IS THE 5TH DIMENSION

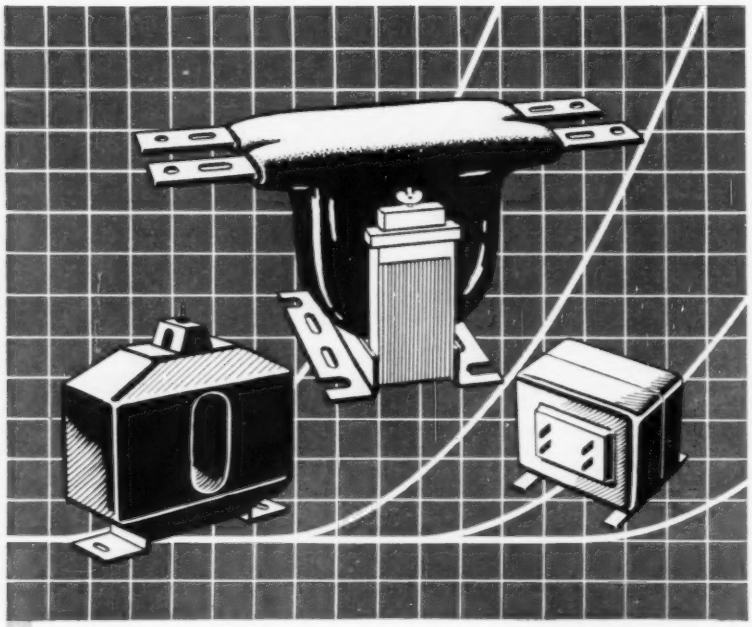
AWARENESS OF PROBLEMS · INTEGRITY OF INTENT · DESIGN EFFORT · MANUFACTURING CONTROL

Please refer to Dept. 117

CANNON ELECTRIC CO., 3208 Humboldt Street, Los Angeles 31, California. Factories in Los Angeles; Salem, Massachusetts; Toronto, Canada; Melbourne, Australia; London, England. Manufacturing licensees in Paris and Tokyo. Representatives and distributors in all principal cities. See your Telephone Yellow Book.

CANNON ELECTRIC

For more information circle 40 on reader service card.



NEW HYSOL 6900

Epoxy Resin lowers cost, provides new ease of handling in casting transformers:

You save money two major ways when you use the four new HYSOL 6900 epoxy casting resins: They cost less per pound, and they provide greater ease in handling.

Longer pot life, low viscosity, and the elimination of filler settling make HYSOL 6900 products more suitable for continuous production techniques – and eliminate the problem of storage.

Specifically developed for casting transformers, coils, magnetic amplifiers, and similar equipment, these new flexible 6900 products can help you lick your casting problems.

Write today for Technical Data Bulletin 6900-1.

HOUGHTON LABORATORIES INC.
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CULVER CITY

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HYSOL (CANADA) LTD.
TORONTO 17

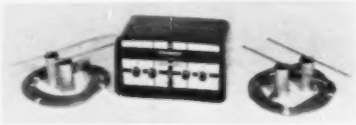
PROGRESSIVE PRODUCTS THRU CHEMICAL RESEARCH
HYSOL
Product of HOUGHTON LABORATORIES, INC.

For more information circle 41 on reader service card.

New Products

(Continued from page 46A)

Electro-Sentry may be connected to a centralized police warning system, or the system may be hooked up to bells, horns, whistles, or sirens. It will also turn on lights, open doors, raise or lower objects, activate displays, operate cameras or recording equipment, or do them all simultaneously. The unit may be operated either indoors or outdoors. The Electro-Sentry cannot harm human beings even if



they touch the sensor units while the set is on. Portability of the unit is limited only by the availability of standard house current. It is also possible to use the Electro-Sentry in field applications, inasmuch as, with slight modification, the unit can be battery operated. *Circle 218 on the card.*

Resistance-Capacity-Ratio Bridge Kit. A resistance-capacity-ratio bridge in kit form has been announced by the Paco Electronics Company, Inc., a newly formed division of the Precision Apparatus Company, 70-31 84th St., Glendale 27, L. I., N. Y. Designated as the Model *C-20*, the new bridge kit is expected to find wide application in radio and television servicing, high fidelity custom building and service, electronic hobbies and amateur radio, science education and technical schools, as well as industrial testing and quality control. Detailed information on the entire company line may be obtained on request. *Circle 219 on the card.*

Microfilm Camera has Automatic Exposure. The *MT/O* 35-mm microfilm planetary camera for high speed and error proof production has been introduced by Microline Products Group, Ozalid Division, General Aniline and Film Corporation. Automatic exposure control of the *MT/O* compensates for variations in voltage as well as background density and gives the exact exposure time which results in high fidelity microfilm of even density. This eliminates the need for light meters, voltage controls, and other special engineering camera accessories. Reduction range is 12× to 30×. Variable copy table height from 3 feet downward permits the operator to sit or stand. Camera is operated either by foot pedal or hand control. The 40-inch by 60-inch copy table accommodates all drawings through *E* size (37½ inches by 52½ inches). For further information about the *MT/O* microfilm camera and other microfilm equipment and supplies, write Microline Products Group, Ozalid Division, General Aniline and Film Corporation, 12 Corliss Lane, Johnson City, N. Y. *Circle 220 on the card.*

All Hughes diodes resemble each other—externally. Germanium point-contact or silicon junction, they are all glass-bodied* and tiny (maximum dimensions: 0.265 by 0.107 inch). But minute, meticulously controlled variations in the manufacturing process impart individual characteristics to the diodes, make them just right for specific applications. This gives you the opportunity of selecting from a line which includes literally hundreds of diode types.

So, when your circuitry requires varying combinations of such characteristics as... high back resistance...quick recovery... high conductance...or high temperature operation, *specify Hughes*. You will get a diode with mechanical and electrical stability built in. You will get a diode which was manufactured first of all for reliability.

*Nowhere else have glass packaging techniques been developed to a comparable extent, for the Hughes process has many unique aspects. They are difficult to duplicate, yet are instrumental to the manufacture of diode bodies which are completely impervious to contamination and moisture penetration.

For descriptive literature please write: **SEMICONDUCTOR DIVISION, HUGHES PRODUCTS**
International Airport Station, Los Angeles 45, California

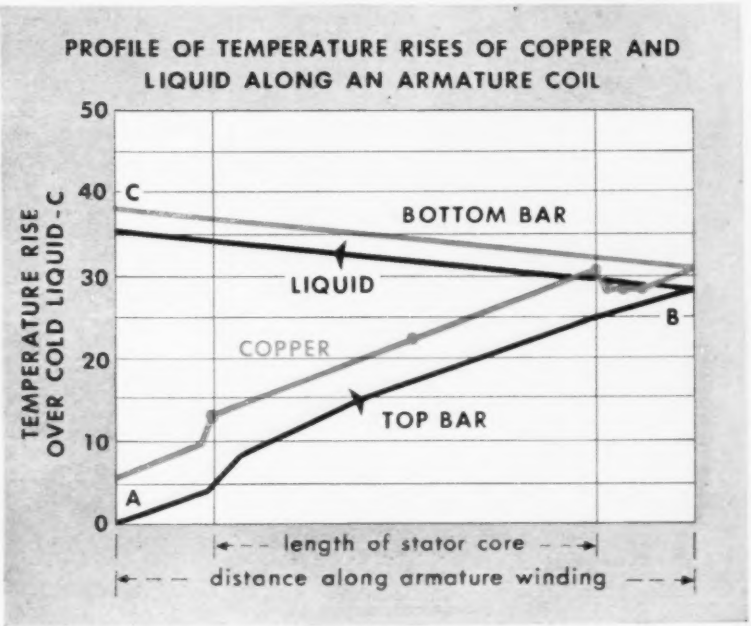
HUGHES
SEMICONDUCTORS

Creating a new world with ELECTRONICS

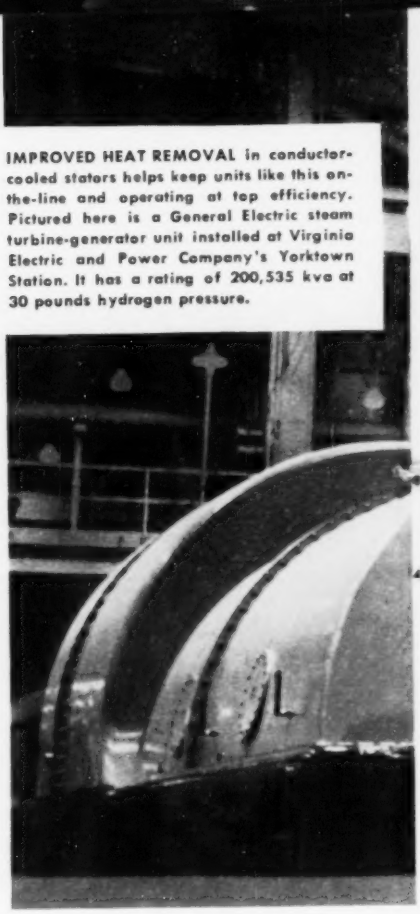
HUGHES PRODUCTS

© 1958, HUGHES AIRCRAFT COMPANY

For more information circle 42 on reader service card.



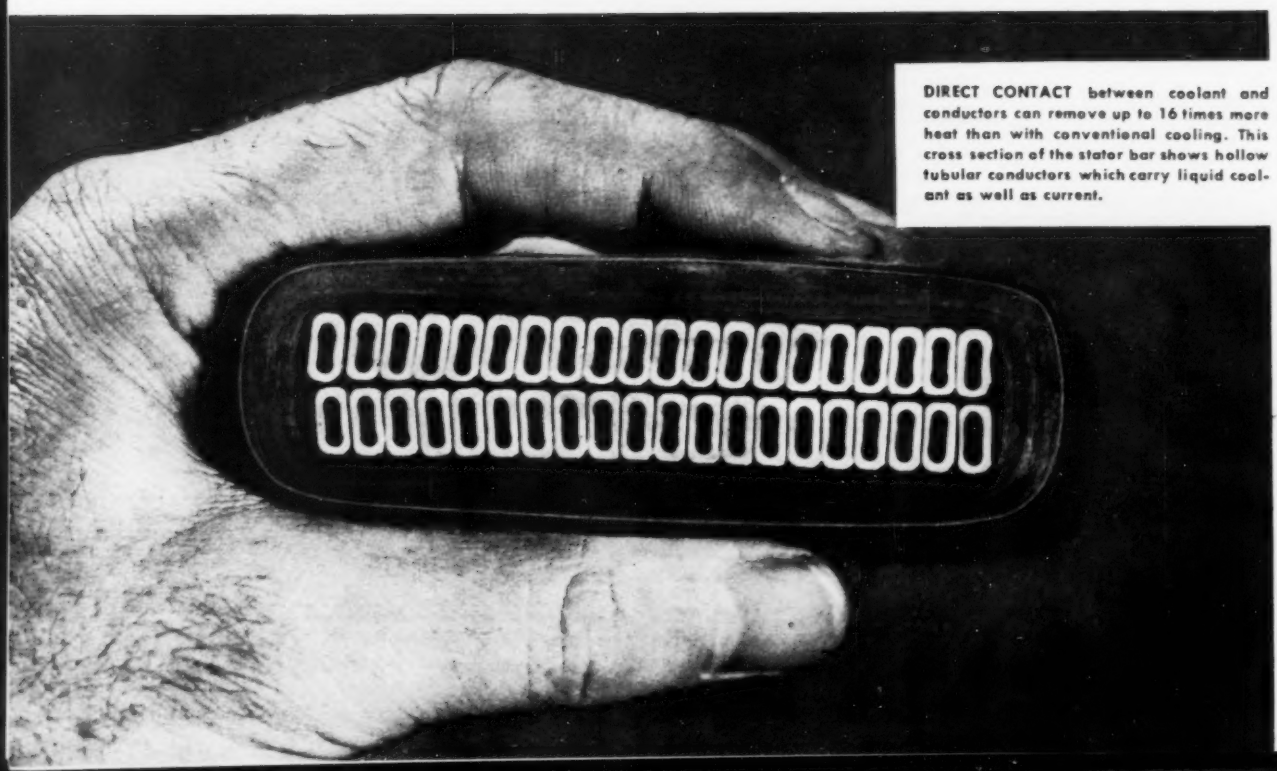
AUTOMATIC TEMPERATURE REGULATION of stator is permitted with liquid cooling. This chart shows how copper temperature remains within a few degrees of the liquid coolant.



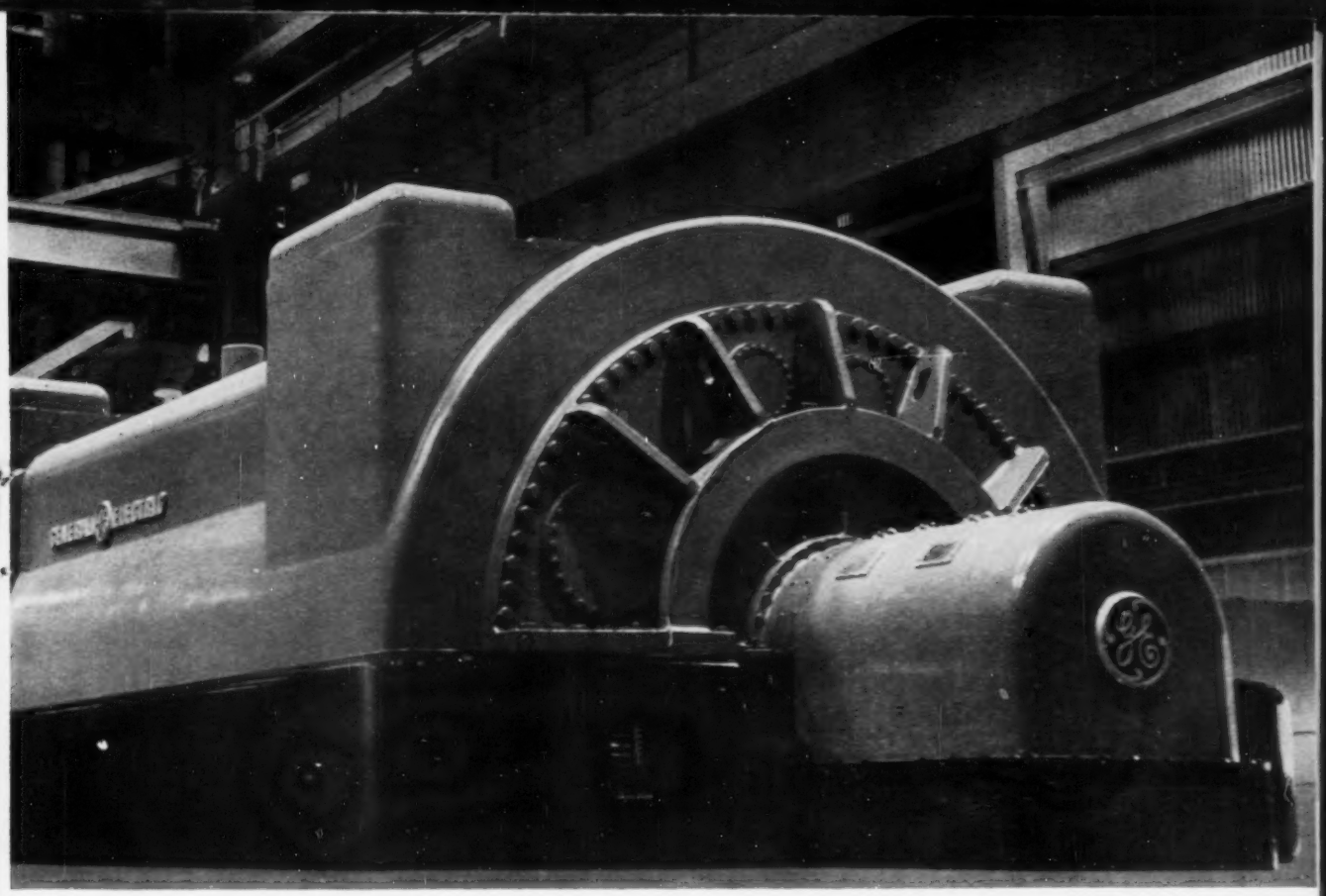
IMPROVED HEAT REMOVAL in conductor-cooled stators helps keep units like this on-the-line and operating at top efficiency. Pictured here is a General Electric steam turbine-generator unit installed at Virginia Electric and Power Company's Yorktown Station. It has a rating of 200,535 kva at 30 pounds hydrogen pressure.

WITH GENERAL ELECTRIC CONDUCTOR-COOLED GENERATOR STATORS . . .

Liquid cooling removes up to 16 times



DIRECT CONTACT between coolant and conductors can remove up to 16 times more heat than with conventional cooling. This cross section of the stator bar shows hollow tubular conductors which carry liquid coolant as well as current.



more heat, permits higher unit ratings

HOLLOW-STRAND STATOR BARS HELP IMPROVE GENERATOR PERFORMANCE

First placed in operation in 1956, liquid-conductor-cooled stators are proving to be one of the most significant advances in generator cooling since hydrogen cooling was introduced some 20 years ago.

Improved Hollow-strand stator bar construction plays an important role in liquid cooling. By providing direct contact between the cooling liquid and the copper current-carrying conductors, *up to sixteen times more heat can be removed than with conventional cooling.* The result is higher generator ratings without appreciable size increase.

Design Features such as use of Micapal insulation for improved dielectric characteristics, bar transposition for uniform temperature, high temperature brazing of liquid connections to prevent leakage, and non-corrosive characteristics of the coolant for longer life, all contribute to more dependable operation.

Improved heat removal for better generator performance is just one of many features of General Electric liquid-conductor-cooled generator stators. Other outstanding advantages are:

Design Simplicity—*Despite higher ratings made possible by liquid cooling, the dielectric system maintains the simplicity and dependability of conventionally-cooled machines.*

Reliable Performance—*Liquid cooling permits automatic regulation of temperature independent of load.*

Dependable Operation—*Closed cooling system minimizes chemical contamination and helps prevent foreign material from entering the system.*

Shorter Maintenance Inspections—*Simple single-stage, low-pressure hydrogen circulating fans permit easy inspection.*

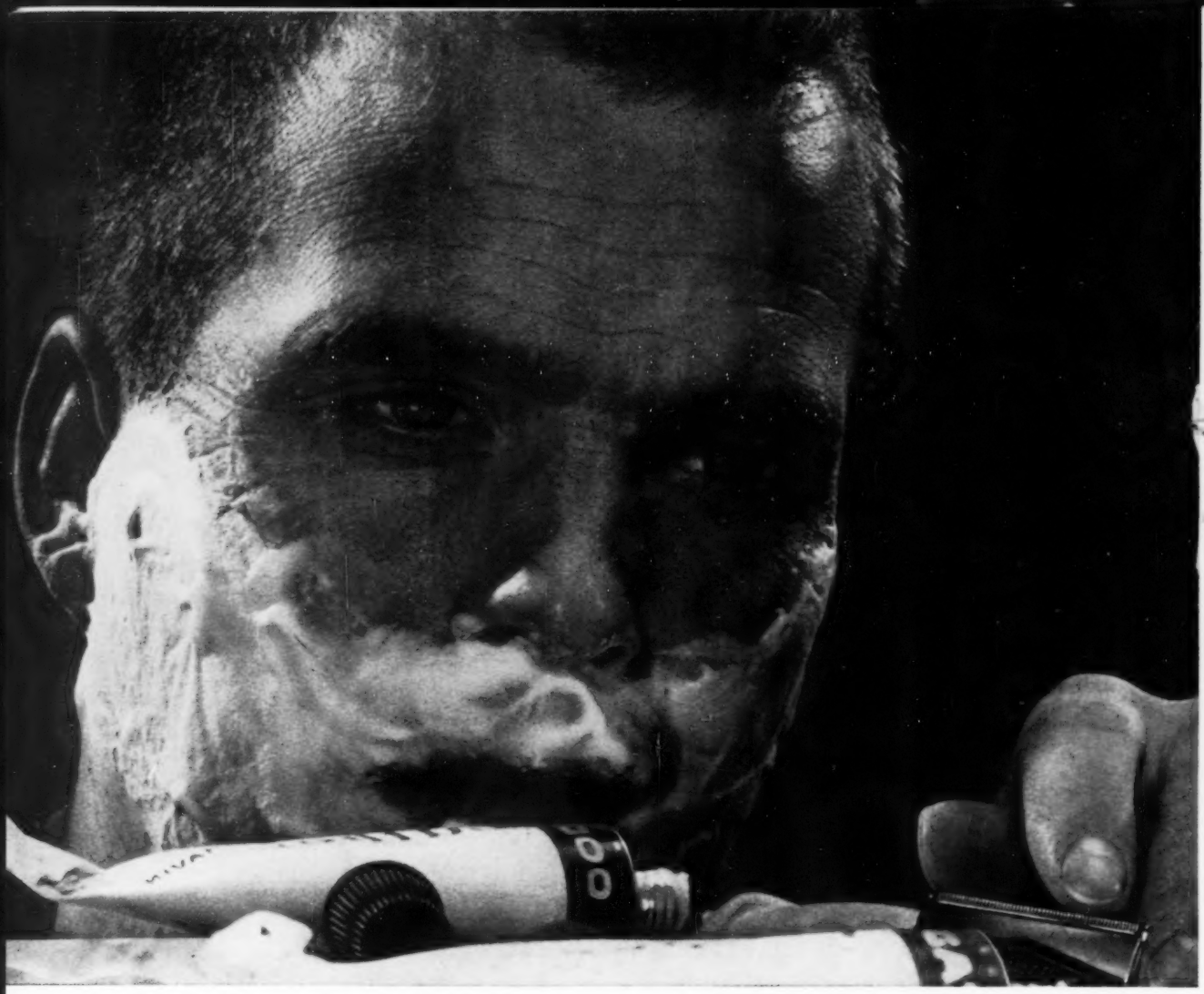
For more information on liquid cooling, write for GER-1231. Large Steam Turbine-Generator Department, General Electric Co., Schenectady 5, N. Y.

254-63

Progress Is Our Most Important Product

GENERAL ELECTRIC

For more information circle 33 on reader service card.



Do you think about the cost of new control circuits
WHEN YOU'RE SHAVING?

Many of your control circuit installation problems, including the cost problem, can be solved if you'll specify and use Rockbestos PNR 600 volt control cable — the cable that's been service proven over and over again through more than 14,000,000 feet of installations.

Here's why Rockbestos PNR is your best buy in control cables:

- Rockbestos PNR lets you pull a 12 conductor control cable in conduit which is now carrying ordinary six or seven conductor cable.
- With it you save on conduit and fittings, cut installation costs.
- It's 46% smaller in area — 28% smaller in diameter than conventional control cable.
- It's flexible from 167° to −67°F.
- It's light, easy to handle, pull through conduits.

Get the complete Rockbestos PNR story — write now for detailed specifications and application data.

ROCKBESTOS PRODUCTS CORPORATION
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NEW YORK, CLEVELAND, CHICAGO, PITTSBURGH, LOS ANGELES, DETROIT, ST. LOUIS, ATLANTA, DALLAS, OAKLAND, SEATTLE

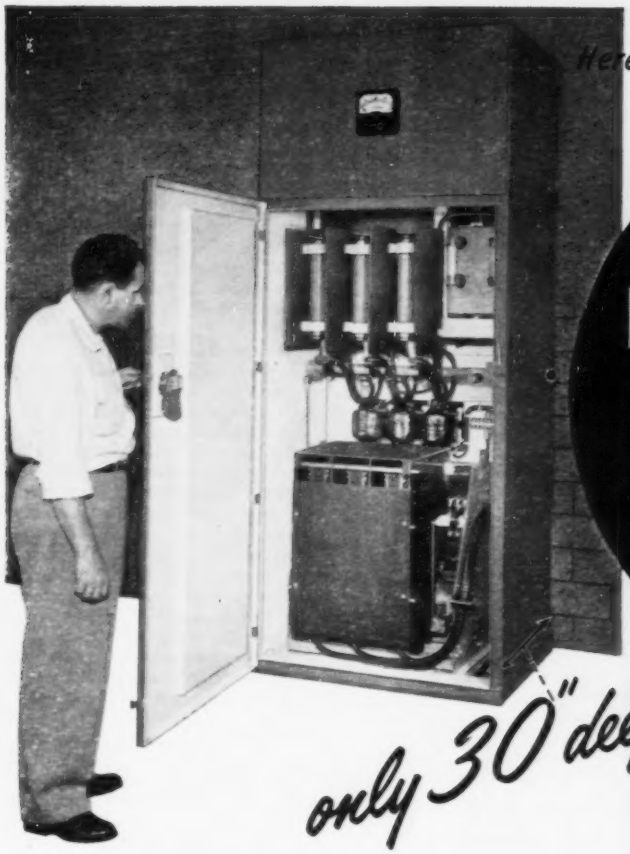
ROCKBESTOS

PNR Small Diameter Control Cable

More than 14,000,000 Feet in Service

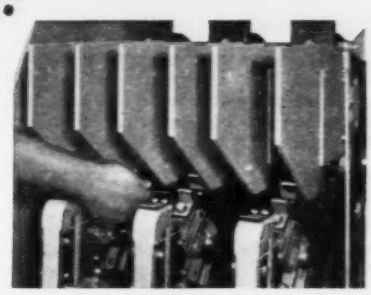
For more information circle 59 on reader service card.

Here is **DESIGN LEADERSHIP...** *in Action!*



3-way Padlock Protection WITH EC&M Air-Break High Voltage (2200-4800 VOLTS) Starters

only 30" deep!



NO DRAW-OUT NEEDED • Arc shields slide out horizontally, making front and rear contact-tips removable with standard wrench.

Accessible from Front...

(Solid back) • Starters may be mounted against wall or in double row, back to back

EC&M's door-and-disconnect interlocking system gives you 3-way padlocked safety. The gang-operated Disconnect Switch may be padlocked (**1**) in the "ON" position or (**2**) in the "OFF" position—both with the starter door closed. (**3**) The door opens only by backing out captive thumb screws after the contactor and disconnect are open. For **COMPLETE SAFETY**—Disconnect Switch blades engage grounding clips in the open position.

EC&M's simple interference interlock permits manual operation of the contactor to check contact alignment, shaft rotation, and electrical interlock engagement. No roll-out is needed for any maintenance—contacts, operating coil, and control contacts are fully accessible within the enclosure.

EC&M starters are furnished with a control transformer. Since the bus is located in an isolated upper compartment, only one feeder is required for a group of starters.

Write for **BULLETIN 8130-F**

3 Interrupting Ratings for Squirrel Cage, Synchronous and Wound-rotor Motors

1. CLASS E 1 • 50,000 KVA (symmetrical) based on certified tests.

2. CLASS E 2 • With current limiting fuses and high interrupting capacity contactor. At 2300 volts: 150,000 KVA, 3 phase; 60,000 RMS amperes asymmetrical. At 4,800 volts: 250,000 KVA, 3 phase; 60,000 RMS amperes asymmetrical.

3. VALIMITOR® • May be used on a bus of unlimited short circuit capacity, through the use of a contactor with an interrupting rating of 50,000 KVA, and reactors which limit any fault current to a maximum of 25,000 KVA.

THE ELECTRIC CONTROLLER & MFG. CO.
A DIVISION OF THE SQUARE D COMPANY
CLEVELAND 28 • OHIO

7955-R

For more information circle 45 on reader service card.

Tarzian
SILICON RECTIFIERS

5 basic series of Tarzian Silicon Rectifiers are available for prompt delivery . . . A wide variety of sizes, ratings and mountings assure you of the right rectifier for your application . . . Call your nearest authorized Sarkes Tarzian distributor or sales representative for complete information.

TUBE REPLACEMENT SERIES

Direct plug-in replacements for rectifier tubes are available in five types that cover 95% of the popular octal types in use. The additional efficiency, ruggedness and long life makes this series popular in equipments where unattended service and dependability are prime considerations.

HEAVY CURRENT SERIES

The high current series covers current ratings of 25, 35, 100, 150 and 200 amperes at peak inverse voltage ratings of 50, 100, 200 and 300 volts. The unique package design provides maximum heat transfer from the junction to the heat sink through the shortest possible path.

HIGH VOLTAGE SERIES

Series junctions provide the solutions to the high voltage problems, when dependability is also a prime requirement. The peak inverse voltage range is from 800 to 2800 volts and the dc current ratings are from 325 to 450 milliamperes at 100°C.

HERMETICALLY SEALED SERIES

This series, ranging in voltage ratings from 50 to 400 volts peak inverse and current ratings from 500 milliamperes to 15 amperes, is completely hermetically sealed to meet military requirements. Both axial lead and stud mounted types are available.

L AND M SERIES

Type L and type M silicon rectifiers are designed primarily for commercial use and are provided with end ferrules that fit standard fuse clips. A grooved ferrule at the positive end identifies polarity. The current ratings are: 500 milliamperes on the M series and 1.5 amperes on the L series. The peak inverse voltage range is from 100 to 400 volts.

Sarkes Tarzian, Inc.

RECTIFIER DIVISION

DEPT. E-1, 415 NORTH COLLEGE AVENUE
BLOOMINGTON, INDIANA

In Canada: 700 Weston Rd., Toronto 9, Tel. Rogers 2-7535 • **Export:** Ad Auriema, Inc., New York City

For more information circle 46 on reader service card.

Trade Literature

(Continued from page 52A)

Fasteners Catalog. Valuable engineering data on the full line of Simmons special fasteners is provided in this carefully condensed 8-page catalog. Dimensional drawings, specifications, and important features are shown for the link-lock, hinge-lock, spring-lock, quick-lock, roto-lock, and dual lock. Free copies may be obtained by writing to Sales Department, Simmons Fastener Corporation, N. Broadway, Albany 1, N. Y.

Custom Air-Conditioners Bulletin. A 4-page bulletin which describes in detail the complete line of *Mil-Ac* custom air conditioning units is offered by Ellis and Watts Products, Inc. *Mil-Ac* units, built to meet rigid military specifications (*MIL-E-5272*), will operate effectively under extreme climatic conditions from a minus 65 F to a plus 130 F. Designed primarily to condition electronic systems mounted in military trailers, the units are automatically controlled to ventilate, circulate, cool, heat, filter, humidify, and dehumidify. The bulletin contains detailed information on applications, specifications, and other valuable data. For your copy write Ellis and Watts Products Inc., P. O. Box 33, Cincinnati 36, Ohio.

Filing Manual. Handy guides for measuring filing costs and results along with a detailed plan of action to improve efficiency are made available to management in a 28-page manual, "How To Measure Your Filing Costs and Efficiency," published by Remington Rand Division of Sperry Rand Corporation, 315 Fourth Ave., New York 10, N. Y.

Clutch and Brake Catalog. A 28-page illustrated catalog covering the complete line of miniature and subminiature electromagnetic clutches and brakes has been published. Complete information is included on each type of clutch and brake produced, including cutaway drawings, engineering data, schematic diagrams, dimensional data, minimum performance curves, oscilloscope readings, and other technical information. Also included are photographs and description of the company's engineering, design, and manufacturing facilities. A copy of the new catalog is available without charge from Autotronics, Inc., Route 1, Box 812, Florissant, Mo.

A-C Motor Bulletin. Totally protected a-c motors from 1 through 125 hp, are discussed in the 4-page, 2-color Bulletin *B-2506* published by Reliance Electric and Engineering Company. Free copies of the bulletin may be had by writing Reliance Electric and Engineering Company, 24701 Euclid Ave., Cleveland 17, Ohio.

Series 1200 Data Logger Literature. A catalog on Series *1200* data logger featuring building-block construction and flexible pinboard programming has just been issued. Copies are available from Fischer & Porter, 464 Jacksonville Rd., Hatboro, Pa.

(Continued on page 60A)

Kearney's

WESTON

250° SCALE

PANEL METERS

—sizes,
sensitivities,
accuracy,
damping,
to meet your special needs!

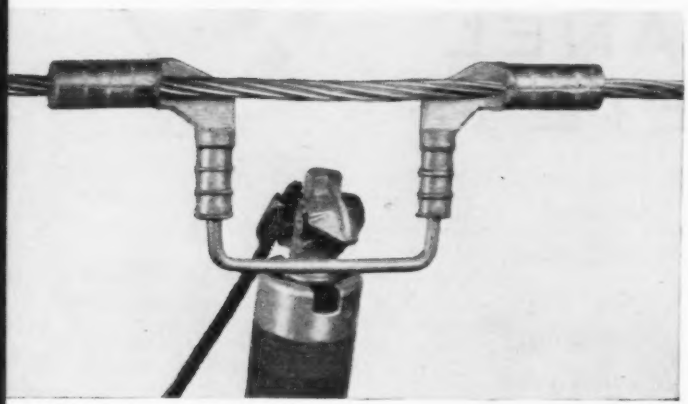
A DAYSTROM UNIT

This comprehensive group of Weston d-c and rectifier type a-c panel meters provides not only increased scale readability, but higher accuracies and improved sensitivities and ballistic characteristics as well. Available in 2½"—3½"—4½" and 5½" sizes, in standard flanged and aircraft cases for a wide range of voltage and current indications, as well as for tachometry and temperature applications. All movements embody Weston spring-backed jewels, and are magnetically self-shielded permitting their use interchangeably on magnetic or non-magnetic panels. For the complete story, consult your nearest Weston representative, or write for literature. Weston Electrical Instrument Corporation, Newark 12, New Jersey.

For more information circle 47 on reader service card.

Kearney's compression program

Added versatility and increased application with existing tools—that's what an investment in Kearney Compression can mean for your system. Besides the basic connections—Squeezons, Serv-En Service Entrance Sleeves, Tension Sleeves and others—you receive the advantages of ever widening tool flexibility as Kearney Engineers continue to develop and introduce new Compression Fittings to the field.

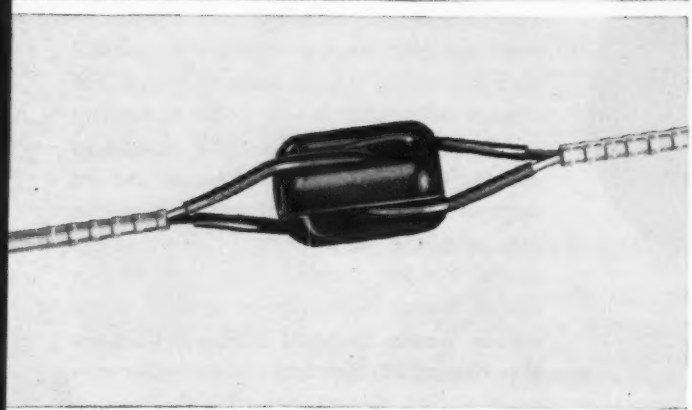


KEARNEY L Squeezon Stirrup

Line side connections are outside the basket—sufficient clearance for either the hydraulic or mechanical tool. The three inch dimension between the line and stirrup makes the unit neat and compact—hot line clamps are readily installed. Unit may be completely covered with line guards.

KEARNEY Compression Terminal

Kearney Compression Terminals provide an efficient method of connecting aluminum conductors to terminal pads. Flaring of strands possible with conventional terminal pads is eliminated. The strands are retained in an aluminum sleeve. Terminals have NEMA 1¾" bolt centers. May also be used as disconnectable jumpers around double dead-ends. The sleeves are filled with Kearnalex Contact Aid and capped and will take conductor sizes from 1/0 to 397.5 MCM 18/1 ACSR.



KEARNEY Insulated Splice

The Insulated Splice was designed primarily for splitting secondaries into shorter sections where additional transformers have been installed and for series street lighting applications. No changes in existing construction are required. Designed for copper, aluminum and ACSR connections, this splice features one piece construction, tension-type sleeves, insulated stainless steel bails and a high strength strain insulator. Splice can be installed with Kearney Hydraulic or Mechanical Tools. ACSR and aluminum sleeves are packed with Kearnalex Contact Aid and plastic capped.

391

JAMES R. KEARNEY CORPORATION • **General Offices: 4224-42 Clayton Ave., St. Louis 10, Mo.**

For more information circle 48 on reader service card.

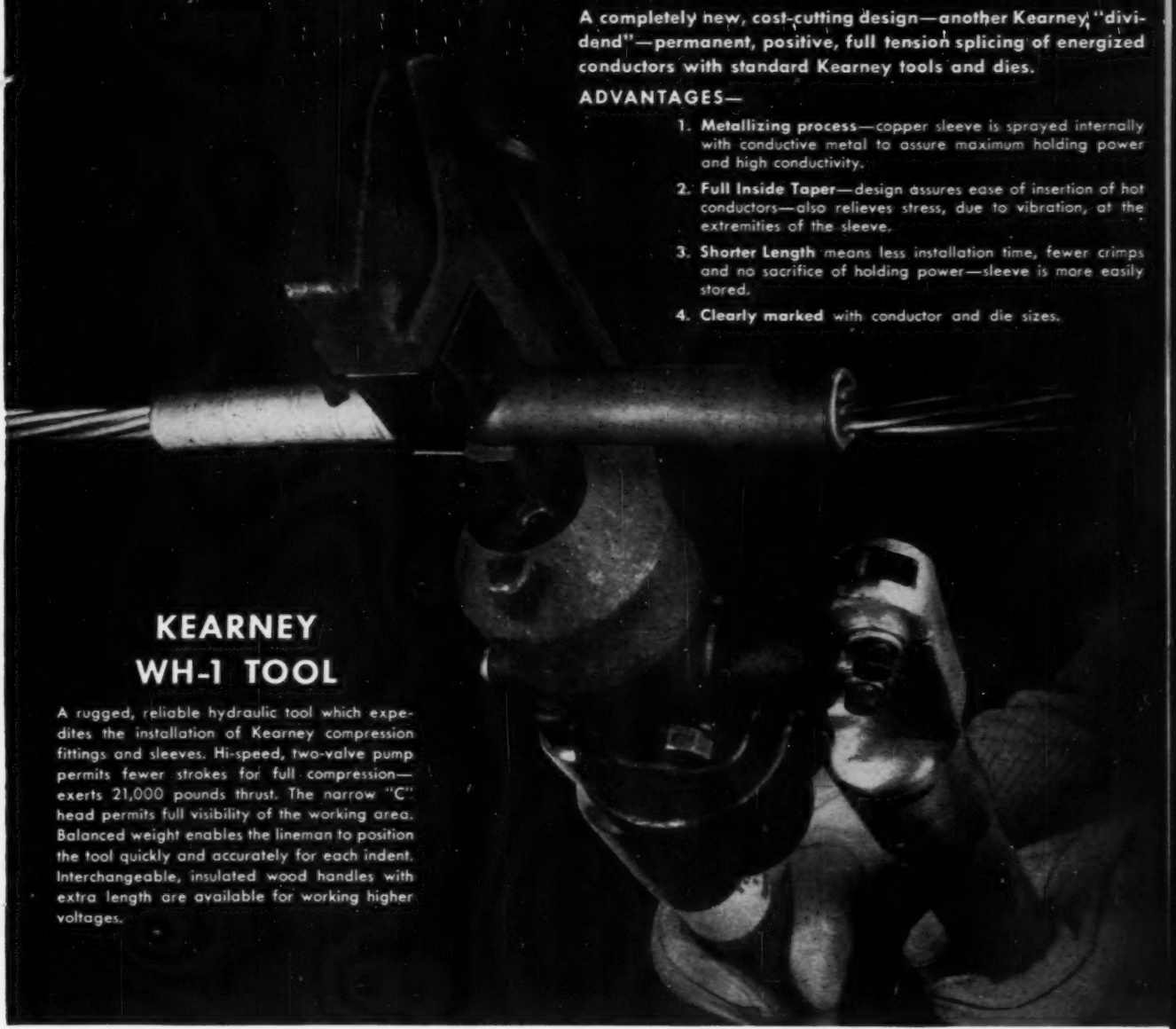
pays extra dividends

KEARNEY INSIDE TAPERED COPPER SLEEVE

A completely new, cost-cutting design—another Kearney "dividend"—permanent, positive, full tension splicing of energized conductors with standard Kearney tools and dies.

ADVANTAGES—

1. **Metallizing process**—copper sleeve is sprayed internally with conductive metal to assure maximum holding power and high conductivity.
2. **Full Inside Taper**—design assures ease of insertion of hot conductors—also relieves stress, due to vibration, at the extremities of the sleeve.
3. **Shorter Length** means less installation time, fewer crimps and no sacrifice of holding power—sleeve is more easily stored.
4. **Clearly marked** with conductor and die sizes.



KEARNEY WH-1 TOOL

A rugged, reliable hydraulic tool which expedites the installation of Kearney compression fittings and sleeves. Hi-speed, two-valve pump permits fewer strokes for full compression—exerts 21,000 pounds thrust. The narrow "C" head permits full visibility of the working area. Balanced weight enables the lineman to position the tool quickly and accurately for each indent. Interchangeable, insulated wood handles with extra length are available for working higher voltages.

FOR BETTER CONSTRUCTION—SAFER MAINTENANCE

Specify Kearney Products

PLANTS AT: ST. LOUIS • FAYETTEVILLE, ARKANSAS • SHENANDOAH & CLARINDA, IOWA • GUELPH, ONTARIO, CANADA

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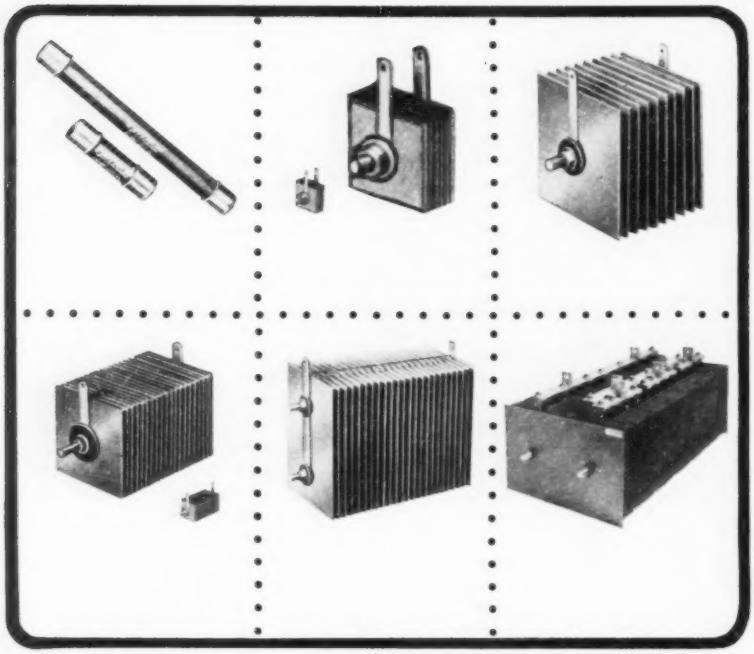
SYNTRON Vacuum Process

SELENIUM RECTIFIERS

for all your d-c needs

. . . the widest range of cell sizes in the industry



SYNTRON SELENIUM RECTIFIERS FEATURES:

- High short circuit surge-current ability to 300 times normal rating
- Withstand high transient conditions without damage
- Cell voltage ratings from 15 to 45 volt RMS means fewer cells per stack
- Protection available for all atmospheric conditions alkaline or acid
- Constructed to withstand high amplitude vibrations

LONGER LIFE TEST PROVES LOWEST AGING, HIGHEST OUTPUT RESULTS IN LONGER LIFE FOR SYNTRON RECTIFIERS.

SYNTRON Selenium Rectifiers consistently outperform and out-last similarly rated rectifiers. Adequate, long lasting circuit control of SYNTRON Selenium Rectifiers is accomplished in the design stages, not by replacement.

SYNTRON Selenium Rectifiers are noted for these exceptional characteristics—lowest voltage drop, lowest leakage current, lowest temperature rise, longest life, greater uniformity from cell to cell and greatest voltage ratings.

E 558

Other SYNTRON Products of Proven Dependable Quality

• SELENIUM RECTIFIER UNITS • ELECTRIC HEATING PANELS • SINUATED WIRE
• ELECTRIC HEATING ELEMENTS • PARTS FEEDERS

Write for complete information on all SYNTRON Products

SYNTRON COMPANY
440 Lexington Avenue Homer City, Penna.

For more information circle 49 on reader service card.

Trade Literature

(Continued from page 56A)

Furnace Equipments Folder. A 12-page folder, "The Tricarb Heat Treating Method," describes the new protected-quench furnace equipments. This equipment features Microcarb atmosphere control, Speedomax temperature control, and a controlled quench. Copies of the descriptive folder are available by requesting Folder *T-620(17)* from Leeds & Northrup Company, 4907 Stenton Ave., Philadelphia 44, Pa.

Advanced Materials Technology. A new publication by The Carborundum Company features technical information on materials to meet severe or unusual conditions in processing or operation, such as extreme heat, abrasive action, corrosion, or other problems beyond the capabilities of conventional materials. "Advanced Materials Technology," published by the Research & Development Division, Niagara Falls, N.Y., is the third of Carborundum's new technical publications. The others are "More Zr Facts" by the Carborundum Metals Company, Akron, N.Y.; and "Carborundum's Refractories" by the Refractories Division, Perth Amboy, N.J. All of the publications are available upon request to the respective Divisions.

Plug Guide. How to select a Cannon plug is concisely described in a new 40-page plug guide, an orientation to the 53,000 connectors manufactured by Cannon Electric Co. Copies of the plug guide are available from Cannon Electric Company, c/o Advertising Department, 3208 Humboldt St., Los Angeles 31, Calif.

Industrial Electric Heating Unit Booklet. A booklet entitled "Industrial Electric Heating Units and Devices" is available from Westinghouse Electric Corporation. The 24-page booklet describes a wide variety of heating units, strip heaters, oven heaters, immersion heaters—bolt heaters and industrial hot plates. Heating problems and their solutions are discussed with the aid of graphs and charts in the booklet's heater selection guide. A complete line of compatible heater control equipment is also featured. For a copy of Catalog *27-620*, write Westinghouse Electric Corporation, P. O. Box 2099, Pittsburgh 30, Pa.

Transistor Manufacturing Brochure. As a service to the electronic industry, a brochure to show the reader exactly how the germanium alloyed junction transistor is manufactured has been published with the help of 15 photographs and a flow chart, this 8-page brochure shows the step-by-step operations in the production of the transistor from raw material to finished product. For a free copy write to General Transistor Corp., 91-27 138th Place, Jamaica, N. Y. Prices for larger quantities on request.

(Continued on page 64A)

Fault currents throttled

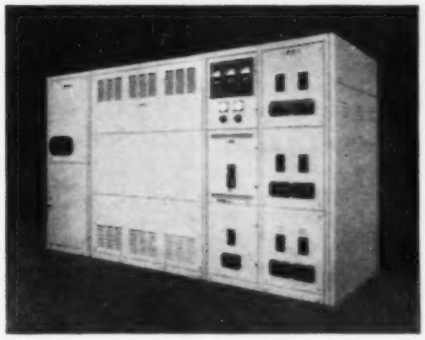
in BullDog Unit Substations

Give your clients the economies of high-voltage distribution and maximum secondary protection with Cordon* breakers in BullDog unit substations. Cordon breakers safeguard circuits *three ways*. Thermal-magnetic action performs in overload and low fault areas. Amp-trap** action limits damaging high fault currents up to 100,000 RMS amperes to low values . . . prevents destruction of equipment by clearing the fault immediately. When any one Amp-trap opens, all breaker poles automatically trip preventing single phasing.

Add to plant safety, economy and production efficiency. Specify BullDog unit substations with Cordon current-limiting breakers. Contact your BullDog field engineer or electrical contractor, or write BullDog Electric Products Co., Detroit 32, Michigan.

© BEPCO

*Trade-mark registered by I-T-E Circuit Breaker Company
**Trade-mark registered by Chase-Shawmut Company



STANDARDIZED CONSTRUCTION of BullDog unit substations allows for easy expansion. Four frame sizes of the 100,000 RMS ampere IC rated Cordon breaker are now available—100, 225, 400, and 600 amps: 600 volt AC; 250 volt DC.

The current-limiting Amp-traps are accessible from the front of the substation for installation or replacement.

BULLDOG

BullDog Electric Products Co., Detroit 32, Mich. A Division of I-T-E Circuit Breaker Co.
BullDog Export Division: 13 East 40th St., New York 16, N.Y.
In Canada: BullDog Electric Products Co. (Canada) Ltd., 80 Clayson Rd., Toronto 15, Ont.

ANSONIA
Ankoseal®

SUPERVISORY CONTROL & STATION CONTROL CABLES

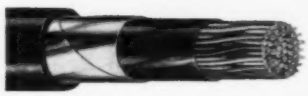
for Industry, Utility and Mechanized Research Applications

ANKOSEAL Quality Makes The Performance Difference

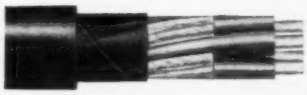
In telephone cables, in railroad cables and now in supervisory control & station control cables, Ansonia Ankoseal provides the best quality and the latest developments.

Whether your control cable installation calls for heavier insulation to give rugged dependable service on critical circuits or for routine smaller current circuits such as telemetering, pilot wire relaying, etc., . . . an Ankoseal cable will serve you best.

ANKOSEAL has just published a complete catalog on their Supervisory and Station Control Cables. Send for your copy NOW!



ANKOSEAL Type 775-P Supervisory Control Cables, 0-300 Volts.



ANKOSEAL Station Control Cables 0-600, 0-1000 and 0-300 Volts.

THE ANSONIA WIRE & CABLE COMPANY · ASHTON 12, R. I.

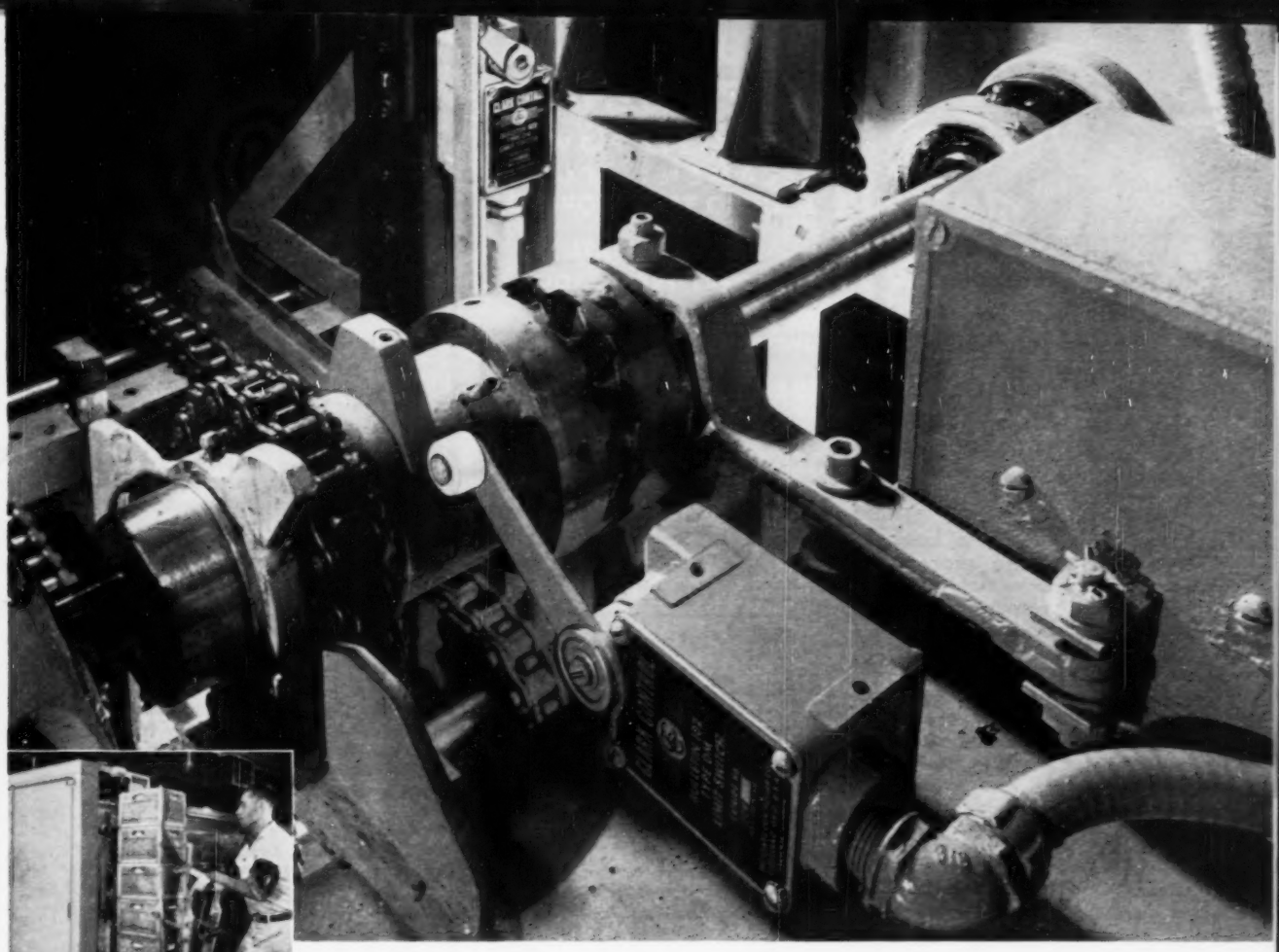
The Oldest Name in Plastic Cables in The Most Modern Plant Devoted Entirely To Producing Plastic Cables

ANSONIA Ankoseal®

ANKOSEAL Cables Built Up To Quality Not Down To Price

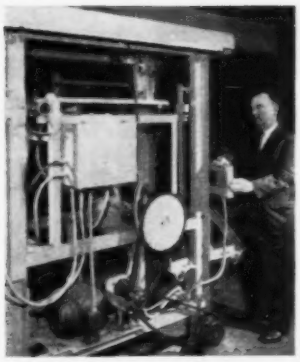
624-7

For more information circle 51 on reader service card.

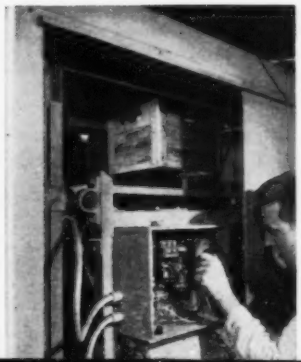


Large illustration above shows a section of the Worcester Automatic Stacker. Two of the six Clark Limit Switches are visible.

Photo top left shows stacked cases being removed from the machine in a dairy.



Robert St. Jean, President of Worcester Automatic Machine Company demonstrates the operation of the Stacker. Side panels have been removed to show working mechanism. Entire operation is automatic.



In addition to the six Clark Limit Switches, the stacker also uses a Clark Bulletin 6013 motor starter (shown in enclosure) and three Clark Bulletin 100 Push Button Stations, one of which is seen at left.

Stacking Machine designed for Ruggedness and Dependability uses CLARK Type "DM" Limit Switches

● Worcester Automatic Machine Company manufactures highly efficient case stackers for dairies and bottling plants. A basic design requirement for these machines is extreme ruggedness to assure dependable, continuous, automatic operation. Limit Switches controlling the sequencing of horizontal and vertical movement of the cases must be accurate and must have the durability to withstand thousands of operations per day, day in and day out.

Robert St. Jean, President of the company and designer of the machine says: "We selected Clark Type "DM" Limit Switches because they match the ruggedness built into the rest of the machine. We like, particularly, their sturdy die-cast case and their smooth, positive snap action resulting from the use of nylon for rollers and latch parts. There are six limit switches—all Clark—on each stacker. In spite of the pounding they take, failures have been negligible".

Clark Type "DM" Heavy-duty Limit Switches are available with a wide selection of mounting arrangements and operating levers to meet any requirement. Write for Bulletin 102 DM

The CLARK CONTROLLER Co.

Everything Under Control • 1146 East 152nd Street • Cleveland 10, Ohio

IN CANADA: CANADIAN CONTROLLERS LIMITED • MAIN OFFICE AND PLANT: TORONTO

For more information circle 52 on reader service card.

Power Supply for Resistance Welding Machines
(April 1952)

AIEE Special Publication S-45 is a report of the AIEE Subcommittee on Power Supply for Resistance Welding Machines. Recognizing that the installation and use of any resistance welding process vitally concerns not only the industrialist requiring the process but also the welding machine manufacturer and the utility supplying the electric power as well, the committee has in this report brought together much pertinent data from the knowledge, literature, and experience in all these fields.

This publication supersedes the AIEE reports of the same title presented in 1940-1. The new work is required by developments in welding machines, new processes, better analysis of certain phenomena (such as measurement of instantaneous loads, and interference between welders), and a clearer understanding of the whole problem of power supply for resistance welders.

This report is not intended to be a complete solution of all welding problems, but should direct attention to the special electrical features involved so that a full analysis developed for a welding project can be readily understood and utilized by manager, master mechanic, and electrical engineer.

Copies are available for the price of $1.00 (no discounts permitted). Address:

Order Department
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 West 39th Street
New York 18, N. Y.

FREED
MIL-T-27A POWER, FILAMENT, PULSE & AUDIO TRANSFORMERS
FOR IMMEDIATE DELIVERY FROM STOCK

POWER TRANSFORMERS-STANDARD
All primaries 105/115/125 v., 60 c.p.s.

Cat. No.	Hi Volt Sec.	ct	DC Volts	DC Amps	Filament #1 Volt	Filament #1 Amp.	Filament #2 Volt	Filament #2 Amp.	MIL Case Size
MGP1	400/200	√	185	.070	6.3/5	2	6.3	3	HA
MGP2	650	√	260	.070	6.3/5	2	6.3	4	JB
MGP3	650	√	245	.150	6.3	5	5.0	3	KB
MGP4	800	√	318	.175	5.0	3	6.3	8	LB
MGP5	900	√	345	.250	5.0	3	6.3	8	MB
MGP6	700	√	255	.250					KB
MGP7	1100	√	419	.250					LB
MGP8	1600	√	640	.250					NB

FILAMENT TRANSFORMERS-STANDARD
All primaries 105/115/125 v., 60 c.p.s.

Cat. No.	Secondary Volt	Secondary Amp	Test VRMS	MIL Case
MGF1	2.5	3.0	2,500	EB
MGF2	2.5	10.0	2,500	GB
MGF3	5.0	3.0	2,500	FB
MGF4	5.0	10.0	2,500	HB
MGF5	6.3	2.0	2,500	FB
MGF6	6.3	5.0	2,500	GB
MGF7	6.3	10.0	2,500	JB
MGF8	6.3	20.0	2,500	KB
MGF9	2.5	10.0	10,000	JB
MGF10	5.0	10.0	10,000	KB

PULSE TRANSFORMERS

Cat. No.	Block'g. Osc.	Int. Coup'g	Low. Pow. Gat.	Pulse Voltage Kilovolts	Pulse Duration Microseconds	Duty Rate	No. of Wdgs.	Test Volt. KVRMS	Char. Imp. Ohms
MPT1	√	√		0.25/0.25/0.25	0.2-1.0	.004	3	0.7	250
MPT2	√	√		0.25/0.25	0.2-1.0	.004	2	0.7	250
MPT3	√	√		0.5/0.5/0.5	0.2-1.5	.002	3	1.0	250
MPT4	√	√		0.5/0.5	0.2-1.5	.002	2	1.0	250
MPT5	√	√		0.5/0.5/0.5	0.5-2.0	.002	3	1.0	500
MPT6	√	√		0.5/0.5	0.5-2.0	.002	2	1.0	500
MPT7	√	√	√	0.7/0.7/0.7	0.5-1.5	.002	3	1.5	200
MPT8	√	√	√	0.7/0.7	0.5-1.5	.002	2	1.5	200
MPT9	√	√	√	1.0/1.0/1.0	0.7-3.5	.002	3	2.0	200
MPT10	√	√	√	1.0/1.0	0.7-3.5	.002	2	2.0	200
MPT11	√	√	√	1.0/1.0/1.0	1.0-5.0	.002	3	2.0	500
MPT12	√	√	√	0.15/0.15/0.3/0.3	0.2-1.0	.004	4	0.7	700

AUDIO TRANSFORMERS
Freqn. resp. 300 to 10000 cps — 2 DB. All Case Sizes A1

Catalog No.	Application	Impedance Prim. Ohms	Impedance CT	Impedance Sec. Ohms	Impedance CT	DC Current Prim. P. Side MA Max. Unbal. MA	DC Current Max Level DBM
MGA1	Single or P.P. Plates — to Single or P.P. Grids	10K	√	90K Split	√	10 10	+15
MGA2	Line to Voice Coil	600 Split		4, 8, 16		0 0	+33
MGA3	Line to Single or P.P. Grids	600 Split		135K	√	0 0	+15
MGA4	Line to Line	600 Split		600 Split		0 0	+15
MGA5	Single Plate to Line	7.6K 4.8T		600 Split		40 40	+33
MGA6	Single Plate to Voice Coil	7.0K 4.8T		4, 8, 16		40 40	+33
MGA7	Single or P.P. Plates to Line	15K	√	600 Split		10 10	+33
MGA8	P.P. Plates to Line	24K	√	600 Split		10 1	+30
MGA9	P.P. Plates to Line	60K	√	600 Split		10 1	+27

Write for further information on these units, or special designs. Send for NEW 48 page catalog. Also ask for complete Laboratory Test Instrument Catalog.

FREED TRANSFORMER CO., INC.
1700 Weirfield Street
Brooklyn (Ridgewood) 27, New York

Circle 53 on the card.

Trade Literature

(Continued from page 60A)

"Motiondiser" Bulletin. Fundametals of motor driven turntable application to exhibit displays and to factory production uses is fully explained in a 24-page, profusely illustrated, brochure. Ask for Bulletin *2050*, Merkle-Korff Gear Co., 213 N. Morgan St., Chicago 7, Ill.

Metal Grating Handbook. An all-inclusive technical publication to represent a product standardization in the metal grating industry has been published by the Metal Grating Institute, One Gateway Center, Pittsburgh 22, Pa. This 2-color handbook contains 32 pages of informative text, schematic drawings, tables, and actual installation photographs as well as complete standards and specifications. It also contains a glossary of terms and definitions used throughout the metal grating industry. The price for "Metal Grating Handbook" is $1.00 per copy. For single or quantity copies contact Metal Grating Institute, Inc., One Gateway Center, Pittsburgh 22, Pa.

Induction Units and Accessories Bulletin. A 12-page catalog which fully describes the complete line of high-frequency induction units and accessories for rapid high-temperature combustion of laboratory samples has been issued by the Laboratory Equipment Division, Lindberg Engineering Company. For copy of Bulletin *T-1067* write to the company at 2444 W. Hubbard St., Chicago 12, Ill.

Hard Anodizing–Precision Plating Brochure. A 20-page brochure entitled, "Precision Finishes on Metals" is offered by Anachrome Corporation, 10647 Garfield St., South Gate, Calif., which is an affiliate company of Anadite, Inc. Particular emphasis is placed on the "Hardas Process" which has been proved to be a good method of hard anodizing.

Transformer Engineering Manual. An engineering manual on four series of dry-type distribution transformers has been published by R. E. Uptegraff Manufacturing Company. Data on these four series are included: 3 to 10 kva, class *H* insulation; 15 to 112½ kva, class *H* insulation; 3 to 112½ kva, class *B* insulation; silicone impregnation for moisture repellence, nondeterioration, and additional overload capacity; and 150 to 500 kva, class *B* insulation. Copies of the new transformer engineering manual, Bulletin *137*, may be obtained from R. E. Uptegraff Manufacturing Company, 299 N. Lexington Ave., Scottdale, Pa.

Booklet on Cams. Recently published is an illustrated booklet which describes complete service for providing industry with special cams of every type, whether the need is for a single piece or for production lots of thousands. Copies of this informative and helpful booklet may be obtained by writing to The American Cam Co., Inc., P. O. Box 2106, Hartford, Conn., Attn: Mr. J. Chase. Ask for booklet No. *SC-1*.

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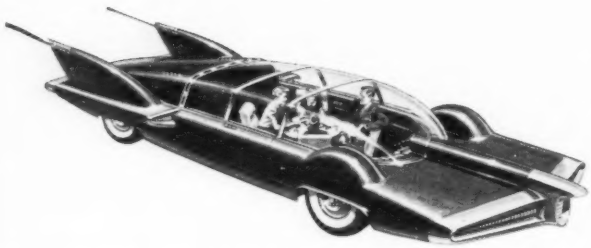

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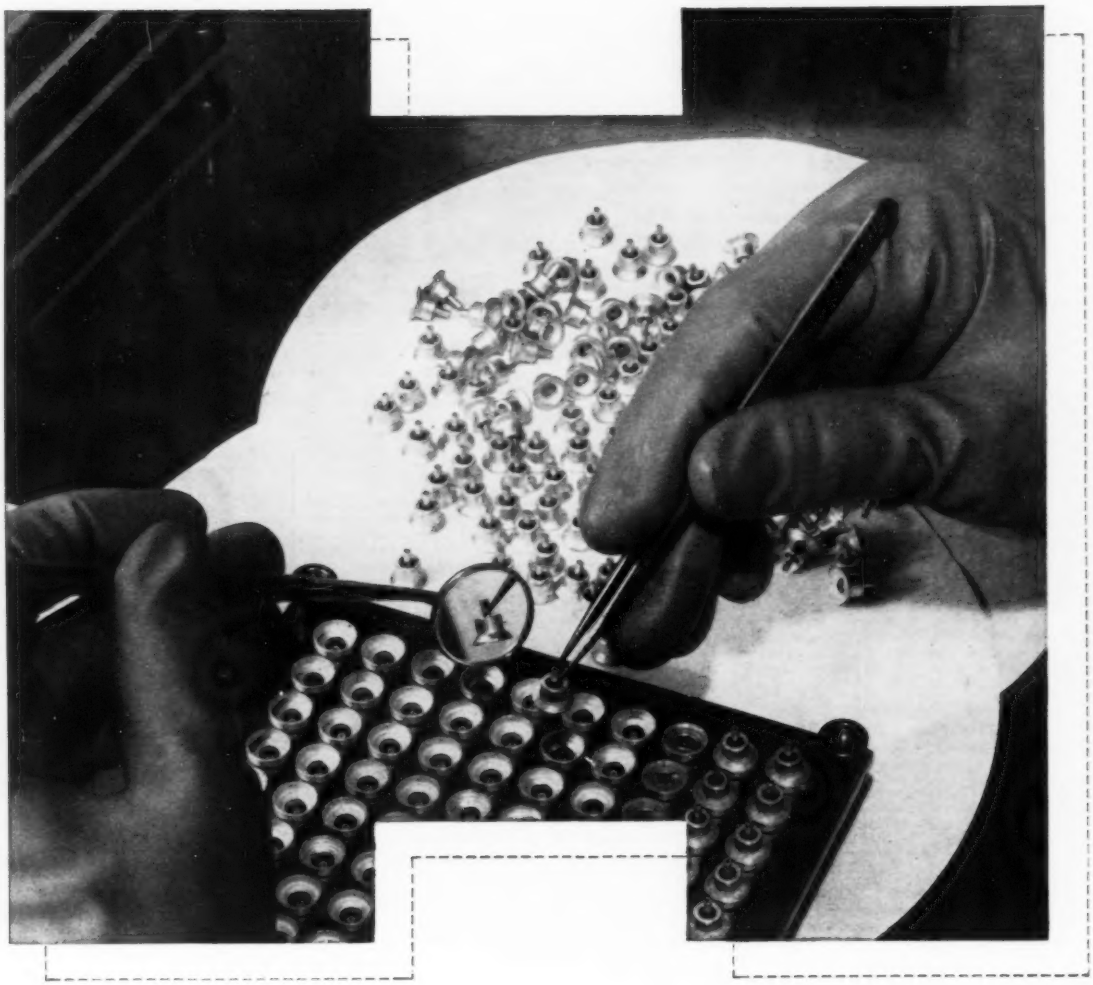

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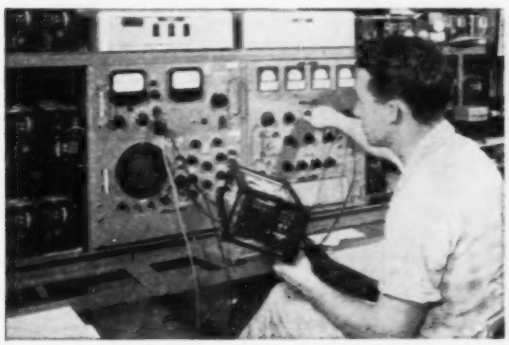

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52 Application Guide for Grounding of Instrument Transformer Secondary Circuits and Cases (March 1951)
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67 Guide for Operation and Maintenance of Turbine-Generators (July 1957)
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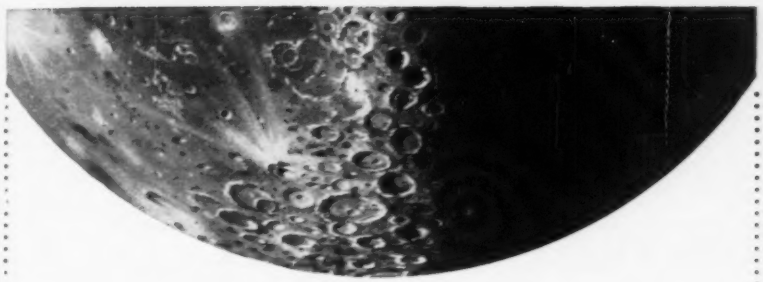

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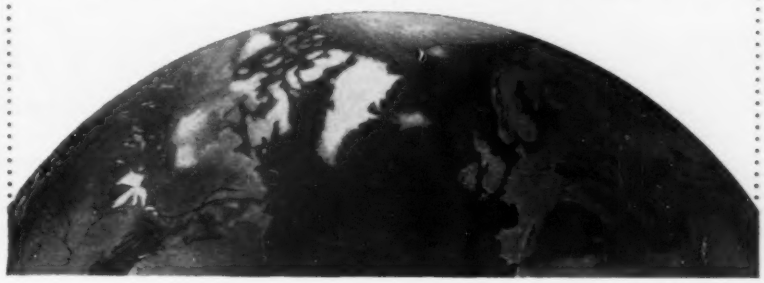

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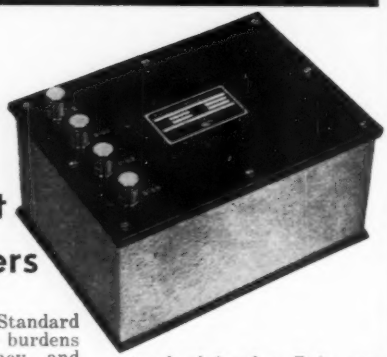

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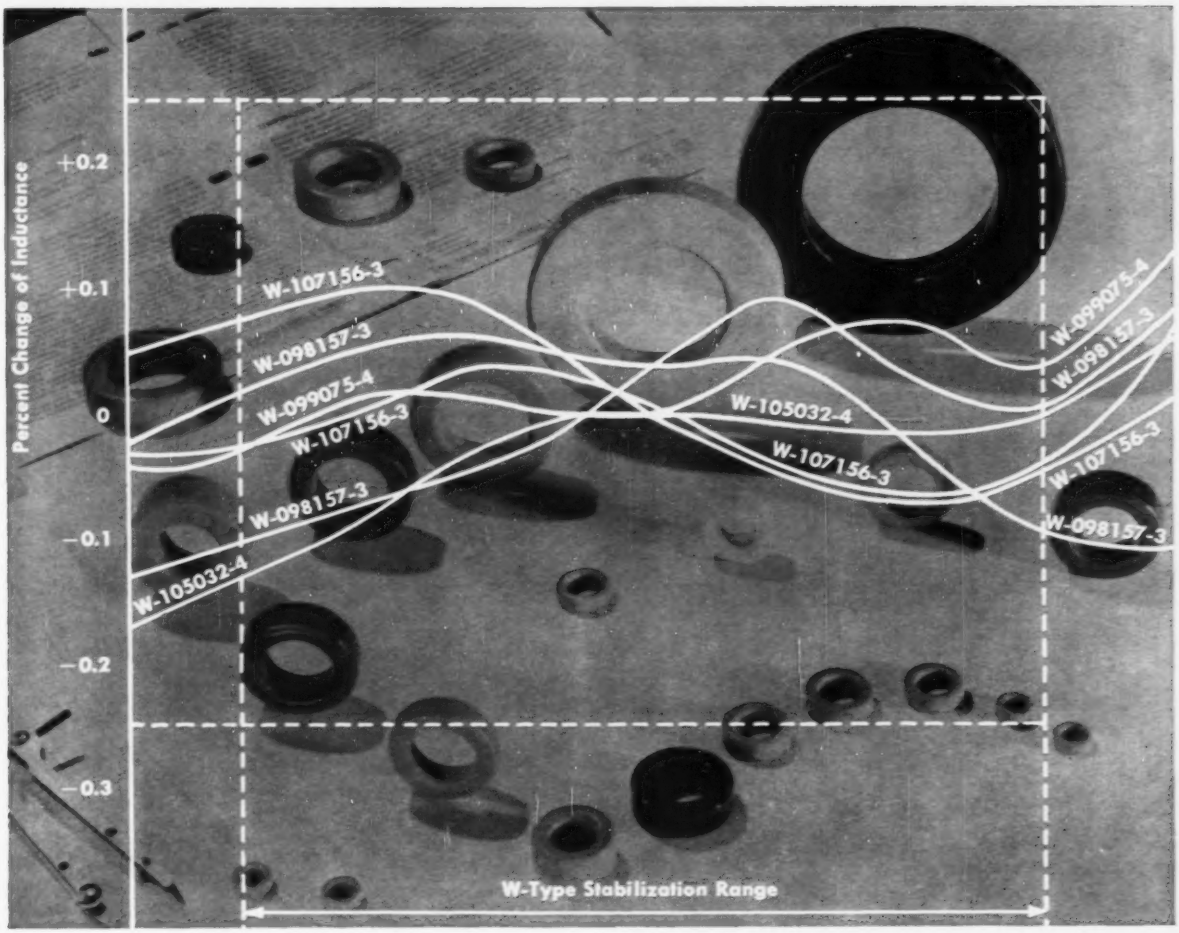

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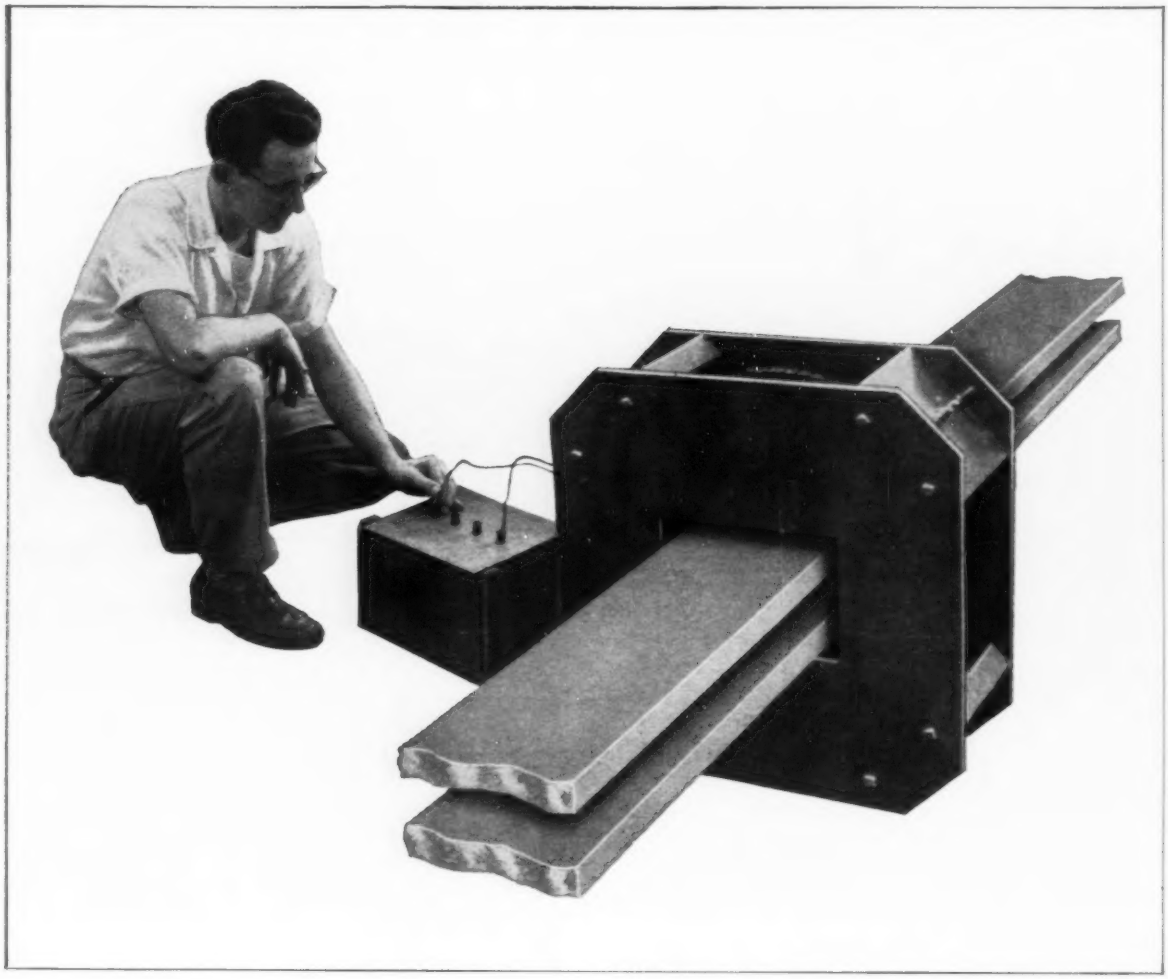

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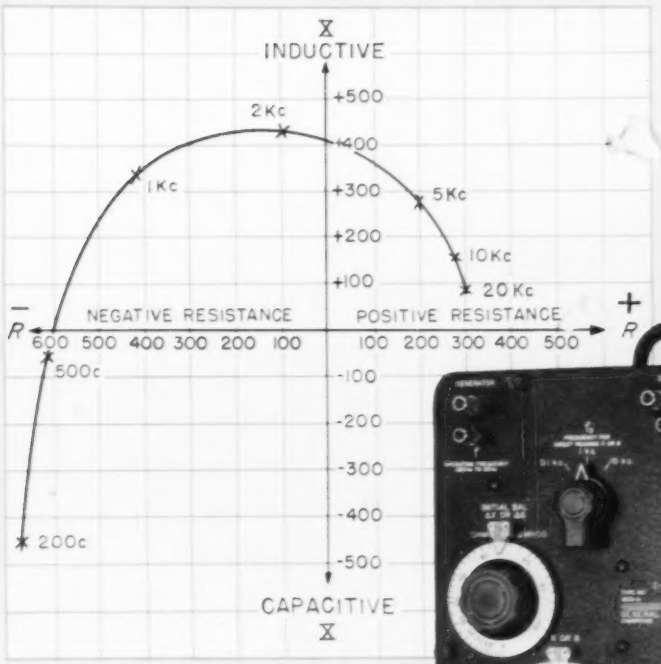
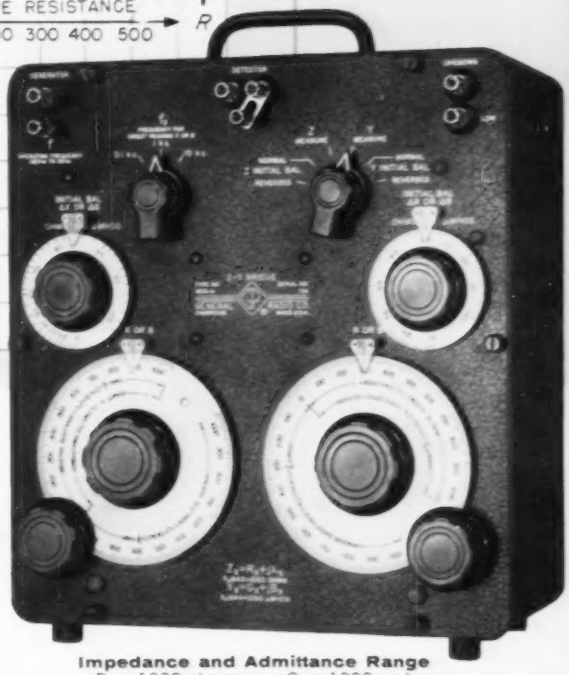


Impedance of Feedback Circuit . . . illustrates ability of the Z-Y Bridge to measure any impedance; quadrature components may be positive or negative, real or imaginary.



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R: ±1000 ohms G: ±1000 μmhos
X: ±1000 ohms B: ±1000 μmhos

Accuracy
R or G: $\pm(1\% + (2 \text{ ohm or } 2\ \mu\text{mho}))$
X or B: $\pm(1\% + (2\frac{f_o}{f} \text{ ohm or } 2f_o\ \mu\text{mho}))$

f is operating frequency, f_o is frequency setting of panel selector switch

Impedances of less than 100Ω (or 100 μmhos) can be measured on "Initial Balance" dials with considerably greater accuracy —
R or G: $\pm(1\% + (0.2 \text{ ohm or } 0.2\ \mu\text{mho}))$
X or B: $\pm(1\% + (0.2\frac{f_o}{f} \text{ ohm or } 0.2f_o\ \mu\text{mho}))$

Frequency Range — 20 cycles to 20 kc

Maximum Applied Voltage
130 volts, rms on bridge;
less than 32v on unknown

Accessories Recommended
Type 1210-B Unit R-C Oscillator and
Type 1212-A Unit Null Detector

Accessories Supplied
2 Shielded Cables for generator and detector

Dimensions — 12½" x 13½" x 8½"

Net Weight — 21½ lbs.

Type 1603-A Z-Y Bridge $370

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- *In speed control of dc motors, two tubes will control 220-volt dc motors rated up to 20 horsepower.*

The 7086 has a high commutation factor, a relatively short dionization time, and a negative-control characteristic that is essentially independent of ambient temperature over the wide range −55° to +75°C because of its xenon gas content.

RCA-7086 DATA

Filament volts	2.5
Filament Amperes	92
Air Flow (cfm)	60
Supply Frequency (cps)	25 to 60

	Continuous Service	Intermittent Service
Peak Anode Volts:		
Forward	650 max.	650 max.
Inverse	650 max.	650 max.
Anode Amperes:		
Peak	160 max.	400 max.
Average	40 max.*	7 max.**

*Averaged over any period of 15 sec. max.
**Averaged over any period of 36 sec. max.

Your RCA Field Representative will be glad to discuss application of this new thyratron with designers of power-control equipment. For a technical bulletin on the RCA-7086, write RCA Commercial Engineering, Section 8-16-Q, Harrison, New Jersey.

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